SECTION 230000 - GENERAL PROVISIONS FOR HEATING, VENTILATING AND AIR CONDITIONING WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work in this Section includes the providing of labor, materials, equipment and services necessary for a complete and safe installation in accordance with the contract documents and all applicable codes and authorities having jurisdiction for heating, ventilating and air conditioning work covered by all sections within Division 15 of the specifications (including but not limited to HVAC systems and equipment).

B. Provide cutting and patching, except as noted in "AIA Document A210" and "Supplementary Conditions for Mechanical and Electrical Work."

C. Provide piping from plumbing terminations, 10 ft from equipment, for water, gas, compressed air and as indicated.

D. Provide drainage from noted equipment to floor drains, roof, sink, or funnel drains.

E. Provide piping connections to equipment, as required, for kitchens, laboratories, laundries, and as indicated.

F. Related Work And Requirements

1. Requirements of general conditions, supplementary conditions for mechanical and electrical work and Division No. 1.

2. Requirements noted under other Divisions of Work

G. **All work shall be in accordance with the International Mechanical Code/2006 as amended by N.J.A.C., Section 5:23-3.20, and Tenant Construction Manual of the Port Authority of New York & New Jersey.**

1.2 WORK NOT INCLUDED:

1. Providing temporary heat.

2. Providing finish painting including pipe stencilling.

3. Providing access doors and filler.

4. Installing access door and providing filler.

5. Providing access doors in concrete for access to fuel-oil tanks.

6. Providing trench covers and frames.

7. Providing chimney cleanout door and thimble.

8. Cutting and patching, except as noted in "AIA Document A201" and "Supplementary Conditions for Mechanical and Electrical Work."

9. Excavating and backfilling under building.

10. Excavating and backfilling.

11. Providing louvers in doors.

12. Providing undercut doors.

13. Providing wall louvers and screens.

14. Providing plenums other than sheet metal.

15. Providing flashing.

16. Providing shaft gratings.

17. Providing equipment platforms.

18. Providing pipe heat tracing system.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications, in general, describe quality and character of materials and equipment.

B. Drawings, in general are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation. Provide additional offsets, fittings, hangers, supports, valves, drains as required for construction and coordination with work of other trades.

C. Scaled and indicated dimensions are approximate and are for estimating purposes only. Before proceeding with work, check and verify all dimensions.

D. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.

E. Typical details, where shown on the drawings, apply to each and every item of the project where such items are applicable. Typical details are not repeated in full on the plans, and are diagrammatic only, but with the intention that such details shall be incorporated in full.

F. If any part of Specifications or Drawings appears unclear or contradictory, consult Architect and/or Engineer for interpretation and decision as early as possible during bidding period. Do not proceed with work without the Architect's and/or Engineer's decision.

1.4 DEFINITIONS

A. "Furnish" or "provide": to supply, install and make complete, safe, and operable, the particular work referred to unless specifically indicated otherwise.

B. "Install": to erect, mount and make complete with all related accessories.

C. "Supply": to purchase, procure, acquire, and deliver complete with related accessories.

D. "Work": includes labor, materials, equipment, services, and all related accessories necessary for the proper and complete installation of complete systems.

E. "Piping": includes pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and all related accessories.

F. "Wiring": includes raceway, fittings, wire, boxes, and all related accessories.

G. "Concealed": not in view, installed in masonry or other construction, within furred spaces, double partitions, hung ceilings, trenches, crawl spaces, or enclosures.

H. "Exposed": in view, not installed underground or "concealed" as defined above.

I. "Indicated," "shown," or "noted": as indicated, shown or noted on drawings or specifications.

J. "Similar" or "equal": of base bid manufacturer, equal in quality, materials, weight, size, performance, design and efficiency of specified product, conforming with "Base Bid Manufacturers."

K. "Reviewed," "satisfactory," "accepted," or "directed": as reviewed, satisfactory, accepted, or directed by or to Architect and/or Engineer.

L. "Motor Controllers": includes manual or magnetic starters with or without switches, individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.

M. "Control or Actuating Devices": includes automatic sensing and switching devices such as thermostats, pressure, float, flow, electro-pneumatic switches and electrodes controlling operation of equipment.

1.5 QUALITY ASSURANCE

A. All equipment and accessories shall be the product of manufacturers regularly engaged in their manufacture. All items of a given type shall be the products of the same manufacturer.

B. Furnish all equipment and accessories new and free from defects.

C. All electrical equipment shall be listed by Underwriters' Laboratories, Inc. (UL) or bear UL labels.

D. Supply all equipment and accessories in complete compliance with and in accordance with the applicable standards listed in reference standards of this Section and with all applicable national, state and local codes.

1.6 JOB CONDITIONS

A. Inspection of Site Conditions:

1. Before starting work, visit the site and examine the conditions under which the work has to be performed. Report in writing any conditions which might adversely affect the work.

1.7 REFERENCE STANDARDS

A. Published specifications, standards tests, or recommended methods of trade, industry or governmental organizations apply to work in all Sections as noted below:

1. ASHRAE - American Society of heating, Refrigerating and Air Conditioning engineers.

2. AABC - Associated Air Balance Controls.

3. AMCA - Air Moving and Conditioning Association.

4. ADC - Air Diffuser Council.

5. NEMA - National Electrical Manufacturers' Association.

6. ANSI - American National Standards Institute.

7. ASME - American Society of Mechanical Engineers.

8. ASTM - American Society for Testing and Materials.

9. NFPA - National Fire Protection Association.

10. ARI - Air-Conditioning and Refrigeration Institute.

11. UL - Underwriters' Laboratories, Inc.

12. OSHA - Occupational Safety and Health Administration Regulations.

1.8 SUBMITTALS

A. Submit shop drawings product data, samples and certificates of compliance required by contract documents, "AIA Document 201" and "SUPPLEMENTARY CONDITIONS FOR MECHANICAL AND ELECTRICAL WORK."

B. Operating instructions, maintenance manuals and parts lists.

1. Provide five sets of manufacturer's equipment brochures and service manuals consisting of the following:

a. Descriptive literature for equipment and components.

b. Model number and performance data.

c. Installation and operating instructions.

d. Maintenance and repair instructions.

e. Recommended spare parts lists.

2. Assemble manufacturers' equipment manuals in chronological order following the specifications' numbering system using heavy duty three ring binders.

3. Submit valve tag chart.

4. Submit three sets of field test reports including instrument set points and normal operating valves.

1.9 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping and ductwork is prohibited in electric and telephone rooms and closets, elevator machine rooms, and for installations over or within 5 ft of transformers, substations, switchboards, motor control centers, standby power plants, and motors.

B. Branch piping to equipment is acceptable when installed over or within 5 ft of motors.

1.10 DRIP PANS

A. Provide drip pans under piping when installation over or within 5 ft of electrical apparatus is unavoidable or in rooms containing electrical equipment. Pan shall be reinforced, properly supported and made watertight. Provide enclosed type for pressure piping. Extend 1-1/4 in. drain pipe from pan to spill over nearest floor drain or as indicated.

1. Construction shall be 32 oz sheet copper.

2. Construction shall be 18 gauge galvanized sheet steel.

1.11 PRODUCT, DELIVERY, HANDLING AND STORAGE

A. Ship materials and equipment in crated sections of sizes to permit passing through available space, where required

B. Deliver equipment with protective crating and shrink-wrapped covering.

C. Receive and accept materials and equipment at the site, properly handle, house, and protect them from damage and the weather until installation. Replace equipment damaged in the course of handling without additional charge.

D. Store to prevent damage and protect from weather, dirt, fumes, water, and construction debris in clean dry space

E. Arrange for and provide storage space or area at the job site for all materials and equipment to be received and/or installed in this project

F. All exposed openings of equipment, piping and ductwork are to be covered

G. Handle according to manufacturer's written rigging and installation instructions for unloading, transporting, and setting in final location

H. Protect units from physical damage. Leave factory shipping covers in place until installation

1.12 ACCESSIBILITY

A. Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of substantial magnitude shall not be made without written approval.

B. Group concealed valves, expansion joints, controls, dampers, and equipment requiring access, so as to be freely accessible through access doors.

1.13 SPECIAL TOOLS

A. Provide one set of any special tools required to operate, adjust, dismantle or repair equipment furnished under this Division for the Owner's use at the completion of the work.

B. Provide one pressure grease gun with adapters for each type of grease required.

C. Provide one suitable tool case for special tools.

1.14 CUTTING AND PATCHING

A. Provide all carpentry, cutting and patching required for proper installation of materials and equipment specified. Do not cut or drill structural members without review by Architect and Structural Engineer.

1.15 UTILITY CONNECTIONS

A. Arrange for and pay costs for all specified utilities including the following:

1. Connection to utility company mains.

2. Payment of service charges.

3. Provision for temporary utilities.

4. Connect in accordance with authority having jurisdiction.

1.16 PROTECTION OF MATERIALS

A. Protect from damage, water, dust, etc., materials, equipment and apparatus provided under this trade, both in storage and installed

1.17 SUBSTITUTIONS

A. .No substitute material or manufacturer of equipment shall be permitted without a formal written submittal to the engineer which includes all dimensional, performance and material

specifications and is approved in writing by the engineer. Any changes in layout or design brought about by the use of a substitution shall be submitted to the engineer fully designed for review in conjunction with the submittal of the alternate. Any substitution must be submitted with an explanation why a substitution is being utilized. If the substitute is being utilized for financial reasons, the associated credit must be simultaneously submitted. Final acceptance or rejection of any substitution is subject to the owner's review.

1.18 STANDARDS:

A. If any item in the specification, as furnished by the contractor, is manufactured in a location which does not certify ASME/ANSI standards, the contractor is to pay the Owner for ALL expenses incurred by the Owner for an outside testing company to confirm such compliance.

1.19 COORDINATION

A. Arrange for pipe spaces, duct spaces, space for equipment, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

D. Provide coordination drawing for all areas of the work. The drawings shall have the following qualities:

1. Minimum 3/8” scale

2. Clearly show all the work for each trade including, but not limited to hangers, valves, dampers, actuators, access doors and service access requirements for all items.

3. Indicate bottom elevations of all ductwork, electrical conduit, raceways, cable trays, control wiring and piping.

4. Ductwork, piping, and conduit 3 inches and smaller may be shown in single line.

5. Ductwork, piping, and conduit greater than 3 inches shall be shown in double line.

6. Color scheme:

a. Architectural and structural background: Light grey.

b. Ductwork: Black.

c. Equipment and pads: Purple.

d. HVAC piping and equipment: Green.

e. Electrical conduits and equipment: Blue.

f. Plumbing: Orange.

g. Fire protection: Red.

h. Control wiring: Pink.

1.20 GUARANTEE

A. In accordance with General Conditions (AIA Document 201) & Supplementary Conditions for Mechanical & Electrical Work.

B. The Contractor shall furnish a written guarantee to replace or repair promptly and assume responsibility for all expenses incurred for any workmanship and equipment in which defects develop within one year form the date of final certificate for payment and/or from date or actual use of equipment or occupancy of spaces by Owner included under the various parts of work, whichever date is earlier. This work shall be done as directed by the Owner. This guarantee shall also provide that where defects occur, the Contractor will assume responsibility for all expenses incurred in repairing and replacing work of other trades affected by defects, repairs or replacements in equipment supplied by the Contractor.

1.21 PERMITS AND FEES

A. In accordance with General Conditions (AIA Document 201) & Supplementary Conditions for Mechanical & Electrical Work.

B. The Contractor shall give necessary notice, file drawings and specifications with the department having jurisdiction, obtain permits or licenses necessary to carry out this work and pay all fees therefore. The Contractor shall arrange for inspection and test of any or all parts of the work if so required by authorities and pay all charges for same. The Contractor shall pay all costs for, furnish to the Owner before final billing, all certificates necessary as evidence that the work installed conforms with all regulations where they apply to this work.

1.22 INSPECTIONS / TESTING

A. Independent testing and inspections shall be provided by the mechanical contractor who shall hire the inspector or testing agency

1.23 SERVICE AND WARRANTY (MAINTENANCE CONTRACT

Coordinate with owner if emergency service is required. This would be a 2 hour response time during normal hours and 4 hour response time afterhours.

A. This contract shall provide a full year service and warranty of all mechanical components and systems, with add alternate prices for years 2, 3 and 4 following this first year. At the time of acceptance of project, the tenant or owner's representative will decide to accept which alternate, if any.

1.24 RIGGING

A. This contractor shall provide all required rigging, hoisting and bracing to install the equipment as indicated on the plans. This work shall be performed by an insured certified licensed rigging company that is experienced in rigging equipment of the type indicated for the areas shown on the construction documents. This contractor shall submit rigging plans for approval prior to proceeding with the work.

B. All permits required from the authorities and agencies involved to perform the rigging are the responsibilities of this contractor.

C. All structural supports, modifications or additions are to be submitted to the structural engineer for approval prior to proceeding with the work. All supplemental structural supports, elevator charges /modifications, bracing and protection required for the rig is the responsibility of this contractor

D. The rigging contractor shall hire and pay for all charges and services of the building elevator contractor for the rigging of the equipment

PART 2 - PRODUCTS

2.1 BASE BID MANUFACTURERS

A. Base bid on materials or equipment are specified by name of manufacturer, brand or trade name and catalog reference.

B. The choice will be optional with bidder where two or more manufacturers are named.

C. The following are base bid manufacturers for items under this Section:

1. Access doors: Karp Associates, Inc., Higgins Mfg. Co., Milcor Steel Co., and Walsh-Spencer Co.

2. Inserts: F and S Mfg Co., Fee and Mason and Grinnell.

3. Hangers and supports: I.T.T. Grinnell, Carpenter and Patterson, Inc., and Fee & Mason.

4. Paint: Sherwin-Williams, Pittsburgh Plate Glass Co., Pratt and Lambert, and Rust-Oleum.

5. Gratings: Irving Grating IKG Industries and Ryerson - Inland Steel Co.

2.2 INSERTS AND SUPPORTS

A. Support all HVAC work from building construction by providing inserts, beam clamps, steel fishplates (in concrete fill only), and acceptable brackets. Submit all methods for review.

B. Provide trapeze hangers of bolted angles or channels for grouped lines and services.

C. Provide additional framing where building construction is inadequate. Submit for review.

D. Inserts shall be steel, slotted type and factory-painted.

1. Single rod shall be similar to Grinnell Fig. 281.

2. Multi-rod shall be similar to Fee & Mason Series 9000 with end caps and closure strips.

3. Clip form nails flush with inserts.

4. Maximum loading including pipe, contents and covering shall not exceed 75 percent of rated insert capability.

E. Supports from steel decks:

1. Pipes:

a. Hanger spacing: Per 2006 International Mechanical Code.

2.3 SUPPLEMENTARY STEEL, CHANNELS AND SUPPORTS:

A. Furnish supplementary steel, channels and supports required for proper installation, mounting and support of HVAC work.

B. Connect supplementary steel and channels firmly to building construction in an acceptable manner.

C. Determine type and size of supporting channels and supplementary steel. Supplementary steel and channels shall be of sufficient strength and size to allow only a minimum deflection in conformance with manufacturer's requirements of loading.

D. Install supplementary steel and channels in a neat and workmanlike manner parallel to walls, floors, and ceiling construction.

E. All supplementary steel, channels, supports shall be submitted to Structural Engineer for review.

2.4 EXPANSION ANCHORS

A. Provide smooth wall, non-self-drilling internal plug expansion type anchors constructed of AISC 12L14 steel and zinc plated in accordance with Fed. Spec. QQ-A-325 Type 1, Class 3.

B. Do not exceed 1/4 of average valves for a specific anchor size using 2000 psig (13,800 kpa) concrete only, for maximum working load.

C. Provide spacing and install anchors in accordance with manufacturer's recommendations.

2.5 ACCESS DOORS

A. This contractor shall submit to the architect for approval a plan indicating the size (minimum 18" x 18") and location of all access doors required for operation and maintenance of all concealed equipment, devices, valves, dampers and controls. Contractor shall arrange for

furnishing and installation of all access doors in finished construction and include costs in the bid.

B. Access doors will be provided under General Construction Work.

C. Supply access doors for all concealed HVAC items in inaccessible walls and ceilings for complete access, using a with a minimum door size of 12 in. x 12 in. for installation under the General Construction Work. Locating and setting shall be performed after review.

D. Provide access doors for all concealed HVAC items in inaccessible walls and ceilings for complete access, using a minimum door size of 12 in. x 12 in. Locating and setting shall be performed after review.

E. Flush type access doors shall be similar to Karp Type DSC-211 with No. 13 USSG steel doors and trim and No. 16 USSG steel frame, metal wings for keying into construction, concealed hinges and screwdriver operated stainless steel cam lock. Provide lift off type access doors, similar to Karp Type DSC-212, where door cannot swing open.

F. In acoustic tile ceilings, factory finished white access doors shall be similar to Karp Type DSC-210, with No. 13 USSG steel frame, No. 16 USSG steel pan door suitable for receiving tile thickness and hinges that are not visible when door is closed. Access door shall have screwdriver operated stainless steel cam locks finishing flush with tile with a minimum of 2 per door.

G. In plaster ceilings recessed access doors shall be similar to Karp DSC-210-PL, with recess to receive plaster.

H. In fire rated construction provide fire rated access doors, similar to Karp KRP-150-FR, in accordance with applicable code requirements.

I. Access doors shall have one coat of shop-painted zinc chromate primer.

2.6 ACCESS TILE IDENTIFICATION:

A. In removable ceiling tiles, provide buttons, tabs, and markers to identify location of concealed work. Submit for review.

2.7 ACCESS PLATFORMS:

A. Access platforms will be provided under General Construction Work.

B. Provide access platforms for equipment, where indicated or required by authorities having jurisdiction, in accordance with OSHA regulations and indicate on shop drawings, details of construction and method of attachment.

C. Provide removable gratings, toeplates, and guard rails suitable for a minimum 100 pounds per sq ft floor loading.

D. Provide supports riveted or welded structural steel cross-braced on four sides and welded to baseplates for anchor bolting to concrete piers.

E. Gratings shall be similar to:

1. Steel: Irving "x-bar."

2. Aluminum: Irving "x-bar."

3. Fiberglass: Ryerson Duradek I-5000.

2.8 EQUIPMENT PLATFORMS

A. Equipment platforms will be provided under General Construction Work.

B. Provide equipment platforms, where indicated or required by authorities having jurisdiction, in accordance with OSHA regulations and as indicated. On shop drawings, show details of construction and method of attachment. Submit for review.

C. Equipment platform shall be supported from overhead construction. Platform shall be riveted or welded structural steel frame with intermediate framing and clip angles to receive suspension rods. Corners shall be reinforced with gusset plates. Baseplates shall be minimum 10 USSG steel plate riveted or welded to channel iron frame. Where overhead construction does not permit fastening of rods, provide additional steel members framed to span structural steel. Submit for review.

D. Equipment platform shall be supported from floor. Platform shall be riveted or welded structural steel frame with intermediate framing. Corners shall be reinforced with gusset plates. Baseplate shall be minimum 10 USSG steel plate riveted or welded to frame. Supports shall be riveted or welded structural steel, crossbraced on four (4) sides and welded to baseplate for anchor bolting to concrete piers. Submit for review.

E. Fasten vibration isolation bases as noted. Submit for review.

F. Submit shop drawings with details of construction and method of attachment.

2.9 LADDERS

A. Ladders will be provided under General Construction Work.

B. Provide 18 in. wide properly supported, galvanized structural steel ladders designed in accordance with OSHA regulations with 2-1/2 in. x 2-1/2 in. side rails and 3/4 in. diameter rungs installed 12 in. on center.

2.10 SHAFT GRATINGS

A. Shaft gratings will be provided under General Construction Work.

B. Provide shaft gratings suitable for minimum of 100 pounds per sq ft floor loading.

C. Support on structural steel members and indicate on shop drawings, details of construction and method of attachment.

2.11 TRENCH COVERS AND FRAMES

A. Trench covers and frames will be provided under General Construction Work.

B. Covers:

1. Provide 3 ft long, 1/4 in. thick galvanized checkered steel covers with flush drop-type lift handles and means for securing to frame for easy removal.

2. Provide 3 ft long, 1/4 in. thick galvanized expanded and perforated steel covers with flush drop-type lift handles and means for securing to frame for easy removal.

C. Provide 2 in. x 2 in. x 1/4 in. galvanized welded angle iron frame with welded stops and lugs for anchoring into concrete.

D. Supply trench covers and frames for installation under General Construction Work.

2.12 GUARD RAILINGS

A. Guards and railings will be provided under General Construction Work.

B. Provide guards and railings as indicated and/or as required by OSHA and authorities having jurisdiction.

C. Provide removable type guards with clearances for motor adjustments, for belt driven and rotating equipment, with No. 18 USSG steel frames and No. 20 USSG galvanized perforated steel fronts with covered test openings to permit rpm readings without removal. Provide galvanized steel angle or channel supports braced to maintain clearances of moving parts.

D. Provide removable type railings constructed of 1-1/4 in. pipe and rail fittings.

2.13 TAGS:

A. Provide 2 in. round valve tags on all valves and controls of No. 18 BS gauge aluminum with stamped numbers and letters filled in with black paint.

B. Indicate identifying number and system letter on tags, and fasten by heavy aluminum or brass hooks or chains.

C. Tags shall be similar to Seton Name Plate Corporation.

2.14 CHARTS

A. Provide valve tag chart indicating valve number, system, type, size, location and function for all valves.

B. Mount charts on walnut grained wood plaque, with clear plastic laminations covering diagrams.

C. Mount in aluminum frame and glass.

D. Letter and number valves and controls to correspond with designations on metal tags.

E. Fasten charts permanently in locations, as directed, with four brass screws.

F. Supplement numbering and lettering of charts of existing building.

2.15 NAMEPLATES

A. Provide nameplates with inscriptions, subject to review, indicating equipment and voltage. Fasten with epoxy cement or chrome plated screws. Nameplate shall be black Lamicoid sheet with white lettering.

B. Provide nameplates for gauges, meters, instruments, control devices, pilot lamps, transmitters, motor controllers and panel mounted equipment.

PART 3 - - EXECUTION

3.1 EXCAVATION AND BACKFILL

A. Excavate, backfill and restore surface inside building.

B. Excavate, backfill and restore surfaces inside and outside building.

C. Excavate, backfill and restore surfaces outside building.

D. If rock is encountered, excavate to 6 in. below bottom of piping and refill with well tamped sand and gravel.

E. Bank excavated materials adjacent to trench and properly support with sheet piling and braces.

F. Install and maintain guards and keep excavation free of water with attended pumping equipment.

G. No extra compensation will be provided for quicksand, hardpan, or other material encountered in excavating, except rock on unit price basis.

H. Remove bog or other swampy conditions encountered in excavating to one ft below bottom of piping and backfill with well tamped sand, finely crushed stone, or gravel.

I. Immediately after piping is installed, inspected, tested and accepted, remove sheet piling with special care and solidly fill voids without damage to piping. Backfill in a manner to prevent future settlement. Use only good clean loam, clay, sand or gravel that is free from frozen materials, lumps of clay, rocks, boulders, cinders, slag ashes, vegetable or organic materials, or building or other debris, or refuse.

1. Hand fill in 4 in. layers up to 2 ft above pipe and remainder, fill in with 1 ft layers.

2. Tamp and puddle each layer before placing next layer.

3. Allow no stones larger than 2 in. diameter in fill up to 2 ft above piping and allow not stones larger than 4 in. diameter in fill over 2 ft above piping.

J. Restore surfaces, sidewalks, pavements, curbing, lawns, and shrubs that are disturbed or damaged.

K. Dispose of acceptable surplus excavation on site and remove surplus and unsuitable excavated materials from site as directed.

3.2 CUTTING THROUGH CELLULAR FLOORING

A. Cut openings for reception of work in accordance with manufacturer's recommendations and approval and in a manner not to interrupt continuity of electrical raceways.

3.3 PAINTING

A. General:

1. Provide labor, materials, and equipment necessary for field prime painting. Protect flooring and equipment with drop cloths and store paint and materials in a location where directed. Wire brush and remove all oil, dirt, rust and grease before applying paint.

2. Paint all exposed, uninsulated, non-galvanized sheet metal, other than stainless steel and aluminum, with two coats of aluminum paint or alkyd paint of a color as directed.

3. Paint all exposed, uninsulated, galvanized, aluminum and stainless steel sheet metal in finished spaces, including mechanical equipment rooms, with one coat of galvanized iron primers and two coats of alkyd oil paint.

4. Paint insulated piping and equipment covering with one coat of primer sealer and two coats of alkyd oil paint of a color as directed.

5. Factory or field apply one coat of heat resisting paint for steel pipe and finned tube radiation.

6. Paint exposed steel and metal work not furnished with factory-painted finish, structural steel piping support and uninsulated piping with two coats of alkyd oil paint of a color as directed.

7. Paint the following spaces under this contract:

a. Mechanical Equipment rooms.

8. Apply zinc chromate primer for black steel piping, cast iron piping (except underground), steel and iron work and steel tanks before insulation.

9. Dip in zinc chromate primer, uncoated hangers, supports, rods and inserts.

B. Coordinate color of painting to be provided under General Construction Work.

C. Supply and deliver, in original sealed containers, paint of the best grade for its purpose of colors, as selected, and apply in accordance with manufacturer's instructions.

D. Finish painting:

1. Provide finish painting for piping continuously painted in all exposed areas consisting of two finished coats of high gloss medium or long alkyd paint over prime coat of a color shade as accepted after submittal.

2. Utilize color schedule as follows based on Sherwin Williams, name, figure numbers and finish.

a. Condenser water piping --- PALE GREEN, full glass.

b. Hot water, pumped condensate and equipment --- MAGENTA full glass

c. Refrigeration machines and refrigerant piping --- BRIGHT BLUE, full glass.

d. Supply ductwork and fans --- SILVER GRAY, full glass.

e. Control panels --- SLATE GRAY, full glass.

f. Exhaust and return ductwork and fans --- STEEL GRAY, full glass.

g. Vent and relief piping --- RICH BROWN, full glass.

h. Boilers and breeching --- SLATE GRAY, full glass.

i. Fuel and diesel oil --- BLACK, full glass.

3. Place unlisted piping, ductwork or equipment in one of the following classifications and color coded shades as accepted. This corresponds to colors of ANSI A13.1, (Scheme for identification of piping systems).

a. Red for fire-protection materials.

b. Yellow or Orange for dangerous materials.

c. Green or blue for safe materials.

d. Dark Blue or Purple for extra valuable materials.

e. Gray for general equipment.

4. Shades shall be consistent throughout the project.

5. Coat valve, strainer or other appurtenances operating at over 220 o F where bare metal is exposed with Silicone Alkyd Aluminum, 71S30.

E. Paint interior of ductwork as far back as visible from outside, flat black.

F. Apply factory prime coat for pumps, fans, motors, equipment, registers, diffusers, and grilles.

G. Apply on machinery, one shop coat of metal primer and two finish coats of gray engine enamel.

H. Apply on control valve handles, one coat of paint of color as selected.

I. Paint fire dampers with prime coat and second coat of corrosion inhibitive paint.

J. Spot prime coat marred surface of prime coated equipment and piping to match adjacent coat.

3.4 MECHANICAL IDENTIFICATION

A. Refer to identification Section.

3.5 FOUNDATIONS

A. Foundations and concrete will be provided under General Construction Work.

B. Provide concrete as specified herein:

1. One part Portland cement, two parts fine aggregate, and four parts coarse aggregate.

2. Concrete shall be the same consistency as specified under General Construction Work.

3. Provide concrete, poured in place on roughened concrete floor, cleaned and slushed with coat of cement grout. Do not pour foundation unit concrete has set. Foundation shall be puddled and finished smooth.

C. Hold vibration isolation and anchor bolts in position during pour. Set anchor bolts in oversized sleeves with washers and nuts at bottom. Finish bolts shall be slush with nuts on top. Foundations shall extend 6 in. beyond equipment, except as noted.

D. Provide a minimum of 4 in. concrete foundations. Provide a minimum as required for installation of J bolts for foundations under built up air handling units.

E. Forms: Provide 18-gauge galvanized steel form with welded seams and joints, cross-strip bracing welded to top and bottom angle edges and intermediate bracing welded or riveted to sides as required. Bend top and bottom edges to form 2-inch integral internal angles (bend back exposed edges).

F. Forms; Provide moisture-resistant commercial standard fir with non-staining mineral oil interior surface coating with rounded or chamfered edges.

G. Forms: Forms will be provided under General Construction Work.

H. Provide foundations for:

1. Air handling units and floor mounted plenums.

2. Refrigeration equipment.

3. Motor controllers.

4. Motors.

3.6 WATERPROOFING

A. Waterproofing will be provided under General Construction Work.

B. Where any work pierces waterproofing, installation shall be subject to review, provide all necessary sleeves, caulking, flashing and flashing fittings required to make openings absolutely watertight.

C. Flashing:

1. Provide 6 pounds lead.

2. Provide 16 ounces lead coated copper.

3. Provide No. 22 USSG aluminum.

4. Provide galvanized cast iron bottom roof type fittings, similar to Josam No. 26440 or No. 26450 for piping through roof.

3.7 FIELD QUALITY CONTROL

A. Perform tests as noted, and in the presence of Architect and/or Engineer and authorities having jurisdiction.

B. Provide required labor, material, equipment, and connections necessary for tests and submit results for review.

C. Repair or replace defective work and pay for restoring or replacing damaged work due to tests, as directed.

D. Pay for following required services:

1. Licensed Professional Engineer shall be hired by the mechanical contractor for Controlled Inspection.

E. The following services are available from Owner as directed.

F. Tests and instruction: Refer to specification Section ----.

3.8 CLEANING

A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.

B. Clean and repair painted exposed work, soiled or damaged, to match adjoining work before final acceptance.

C. Remove debris from inside and outside of material and equipment.

END OF SECTION 230000

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. HVAC demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

## 1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

C. Welding: Before proceeding, submit the following for review and approval;

1. Proposed procedure conforming to latest revision of:

a. ANSI/ASME B31.1, pressure piping chapter V.
b. ANSI/ASME B31.9, Building Services Piping
c. ANSI 249.1 Safety in Welding and Cutting
d. List of welders qualified per section IX of ASME. Boiler and Pressure Vessel Code including, but not limited to, the following information:

1) Welder's name
2) Welder's Social Security Number
3) Employer's name
4) Name of testing laboratory
5) Procedure tested for including, but not limited to, the following:

a) Date of test
b) Wall thickness
c) Base metal material
d) Electrode
e) Position

6) Type of test performed
7) Result of test
8) Welder's identification symbol
9) Sample of each identification device
10) Certify that each welder has either worked in the procedure or successfully tested in the procedure within the past six months
11) WPQ
12) PQR
13) WPS

2. No reports from any welding inspection agency shall be accepted unless each agency has first requested and obtained qualifications from the office in accordance with rule 16-1 of the Board of Standards and Appeals welding rule.

D. Brazing: Before proceeding, submit the following for review and approval;

1. Proposal procedure conforming to latest revision of:

a. Section IX, ASME boiler and pressure vessel code, welding and brazing qualifications.
b. ANSI/AWS B2.2 Standard for Brazing Procedure and Performance Qualification

2. List of brazers qualified per section IX of ASME. Boiler and Pressure Vessel Code including, but not limited to, the following information:

1) Brazer's name
2) Brazer's Social Security Number
3) Employer's name
4) Name of testing laboratory
5) Procedure tested for including, but not limited to, the following:

a) Date of test
b) Wall thickness
c) Base metal material
d) Brazing filler material
e) Position

6) Type of test performed
7) Result of test
8) Brazer's identification symbol
9) Sample of each identification device
10) Certify that each Brazer has either worked in the procedure or successfully tested in the procedure within the past six months
11) BPQ
12) PQR
13) BPS

## 1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

### 1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

### 1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### 2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

## 2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.

## 2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.
e. Thunderline Link-seal

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: . Include two for each sealing element.
4. Connecting Bolts and Nuts: [**Stainless steel**] of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## 2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

1. Underdeck Clamp: Clamping ring with set screws.

C. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

D. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

## 2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated or Rough brass.

# PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    c. Insulated Piping: One-piece, stamped-steel type with spring clips.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
    g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
    h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.

i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Pipe Sleeves: For pipes smaller than NPS 6.
b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

## 3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
3. Threaded fittings not allowed in glycol system.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

## 3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

## 3.4 DUCT SYSTEMS – COMMON REQUIREMENTS

A. Install ductwork according to the following requirements and Division 15 Sections specifying metal ducts, casings, duct accessories and related components.

B. Drawing plans, schematics and diagram indicate general location and arrangement of duct systems. Indicated locations and arrangements were used to size ducts and calculate friction loss, expansion, fan sizing and other design considerations. Install ductwork as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install ductwork in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install ductwork indicated to be exposed and ductwork in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install ductwork above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install ductwork to permit servicing of C.V. boxes, VAV boxes, dampers, actuators, filters, humidifiers, and as required.

G. Install with indicated horizontal and vertical offset.

H. Install ductwork free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install ductwork to allow application of insulation.

K. Select system components with pressure class equal to or greater than system operating pressure.

## 3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

## 3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

## 3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

## 3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

END OF SECTION 230500

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Rubber expansion joints.
4. Flexible-hose expansion joints.
5. Packed slip expansion joints.
6. Flexible ball joints.
7. Pipe bends and loops.
8. Alignment guides and anchors.

1.3 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

G. PTFE: Polytetrafluoroethylene plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint
5. Coordination:

    a. Coordinate the location of all anchors, guides and expansion devices with the structural engineer.
    b. Submit details for attachment to the building structure to the structural engineer including all loads and supplemental steel.
    c. Coordinate the location of items in this section with access requirements for equipment, valves, dampers, as required for work in other sections, and as indicated on the drawings.

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fittings and loops that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.

1. Manufacturers: Subject to compliance with requirements,:

a. Adsco Manufacturing, LLC.
b. Badger Industries.
c. Hyspan Precision Products, Inc.
d. Metraflex, Inc.

2. Metal-Bellows Expansion Joints for Copper Piping: Single- or multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.
3. Metal-Bellows Expansion Joints for Stainless-Steel Waterway: Single-ply stainless-steel bellows, stainless-steel-pipe end connections, and steel shroud.
4. Metal-Bellows Expansion Joints for Steel Piping: Single- or multiple-ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.
5. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
6. Configuration: Single- or double Double-bellows type, unless otherwise indicated.
7. End Connections: Flanged or weld.

B. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.

1. Manufacturers: Subject to compliance with requirements,:

a. Adsco Manufacturing, LLC.
b. Hyspan Precision Products, Inc.
c. Metraflex, Inc.

2. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
3. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
4. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
5. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
6. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint .
7. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
8. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.

C. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

1. Manufacturers: Subject to compliance with requirements,:

a. Garlock Sealing Technologies.
b. General Rubber Corp.
c. Mason Industries, Inc.; Mercer Rubber Co.
d. Metraflex, Inc.
e. Vibration Mountings & Controls, Inc.

2. Arch Type: arches.
3. Spherical Type: Single or multiple spheres.

a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
c. Minimum Pressure and Temperature Ratings for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).

4. Material: Buna-N EPDM or NR.
5. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

D. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Manufacturers: Subject to compliance with requirements,:

a. Flexicraft Industries.
b. Metraflex, Inc.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with [**solder**-] joint end connections.

a. NPS 2 (DN 50) and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.

3. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with [**solder**-] joint end connections.

a. NPS 2 (DN 50) and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.

4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 (DN 50) and smaller and [**flanged**] [**weld**] end connections for NPS 2-1/2 (DN 65) and larger.

    a. NPS 2 (DN 50) and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
    b. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
    c. NPS 8 to NPS 12 (DN 200 to DN 300): Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.

5. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 (DN 50) and smaller and [**flanged**] [**weld**] end connections for NPS 2-1/2 (DN 65) and larger.

    a. NPS 2 (DN 50) and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
    b. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
    c. NPS 8 (DN 200) and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

E. Packed Slip Expansion Joints: ASTM F 1007, carbon-steel, packing type designed for repacking under pressure and pressure rated for 250 psig at 400 deg F (1725 kPa at 204 deg C) minimum. Include asbestos-free PTFE packing, compound limit stops, and drip connection if used for steam piping.

1. Manufacturers: Subject to compliance with requirements,:

    a. Adsco Manufacturing, LLC. Type RJ
    b. Advanced Thermal Systems, Inc. Thermal Pak-Type TP2
    c. Hyspan Precision Products, Inc.
2. Configuration: [**Single**] [**Single- and double**] [**Double**]-joint class[ **with base, unless otherwise indicated**].
3. End Connections: Flanged or weld ends to match piping system.

F. Packed type: Provide single or double slip, with anchor base except as noted. Provide internal and external guides integral with stuffing box; wrought steel with chromium plating applied directly to polished steel surface. Provide butt weld ends, except as noted.

1. Provide limit stops, capable of holding against full internal thrust.
2. Packing: Provide self-lubricating asbestos-free polytetrafluoroethylene or asbestos-free reinforced teflon type, which can be injected under full line pressure, contained by minimum of 3 teflon non-asbestos rings at each side.

3. Provide joints body of weldable quality carbon steel, ASTM 53 grade B seamless pipe with drip connection if used for steam service.
4. Slip requirements: Provide ASTM A 53 grade B seamless pipe up to and including 12 inch: Schedule 80 and 16 inch through 24 inch: Schedule 60.

    a. Provide wall thickness after machining not reduced more than 1/8 inch.
    b. Provide double layer of chrome plating with minimum thickness 0.001 inch each after buffing. First layer: crack-free hard chrome; second layer: standard hard chrome.

5. Provide welded steel packing cylinder with internal acme thread and male threaded plunger with cylinder welded directly to stuffing box. Minimum number of packing cylinders as follows:

| Expansion Joint Size | Number of Packing Cylinders |
|---|---|
| 1-1/2 inch thru 4 inch | 1 |
| 5 inch and 6 inch | 3 |
| 8 inch and 10 inch | 4 |
| 12 inch and 14 inch | 5 |
| 16 inch and 18 inch | 6 |
| 20 inch and 24 inch | 8 |

6. Pressure ratings:

    a. High pressure steam, high pressure condensate, high temperature water: 150 lb.
    b. High pressure steam, high pressure condensate, high temperature water: 300 lb.
    c. High pressure steam, high pressure condensate, high temperature water: 400 lb.
    d. Pumped condensate return: 150 lb.
    e. Pumped condensate return: 300 lb.

7. Provide all welding in accordance with Section IX of ASME Boiler and Pressure Vessel Code.
8. All welds for 300 lb. and 400 lb. joints shall be subjected to complete radiographic examination. No liquid or dye penetrant indication will be acceptable. Examination shall be as per requirements of Section V of ASME Boiler and Pressure Vessel Code.

G. Flexible Ball Joints: Carbon-steel assembly with asbestos-free composition packing, designed for 360-degree rotation and angular deflection, and 250 psig at 400 deg F (1725 kPa at 204 deg C) minimum pressure rating; complying with ASME Boiler and Pressure Vessel Code: Section II, "Materials," and with ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.

1. Angular Deflection for NPS 6 (DN 150) and Smaller: 30-degree minimum.

2. Angular Deflection for NPS 8 (DN 200) and Larger: 15-degree minimum.
3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
4. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.
5. Manufacturers: Subject to compliance with requirements,:

    a. Advanced Thermal Systems, Inc.
    b. Hyspan Precision Products, Inc.

## 2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Manufacturers: Subject to compliance with requirements,:

    a. Adsco Manufacturing, LLC.
    b. Advanced Thermal Systems, Inc.
    c. B-Line systems, Inc..
    d. Grinnell Corp.

## 2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.
2. Expansion Plug: Zinc-coated steel.
3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi (20.7 MPa) minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

## PART 3 - EXECUTION

### 3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

### 3.2 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Expansion: Install piping to permit free expansion and contraction without damaging piping or construction.

1. Provide offsets, expansion loops, anchors, guides and supports to permit expansion, with stress limits of ASME Code for Pressure Piping for temperature range of 40 deg F to minimum of 20 deg F above maximum system temperature.
2. Steam piping and medium and high temperature water piping shall be cold-sprung.

    a. Piping up to 1-1/2 inch: Cold-sprung 100 percent of expansion.
    b. Piping 2 inch and larger: Cold-sprung 50 percent of expansion.

C. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

### 3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.6 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 15052 "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230516

SECTION 230523 – GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following general-duty valves:

1. Copper-alloy ball valves.

2. Ferrous-alloy ball valves.

3. High-performance butterfly valves.

4. Bronze check valves.

5. Gray-iron swing check valves.

6. Spring-loaded, lift-disc check valves.

7. Bronze globe valves.

8. Cast-iron globe valves.

1.03 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. SWP: Steam working pressure.

1.04 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.05 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set globe valves closed to prevent rattling.

4. Set ball valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Gear Drive: For quarter-turn valves NPS 8 (DN 200) and larger.

2. Handwheel: For valves other than quarter-turn types.

3. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller.

G. Extended Valve Stems: On insulated valves.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.

1. Solder Joint: With sockets according to ASME B16.18.

a. Caution: Use solder with melting point below 840 deg F (454 deg C) for angle, check, gate, and globe valves; below 421 deg F (216 deg C) for ball valves.

2. Threaded: With threads according to ASME B1.20.1.

J. Valve Bypass and Drain Connections: MSS SP-45.

## 2.03 COPPER-ALLOY BALL VALVES

A. Manufacturers:

1. Two-Piece, Copper-Alloy Ball Valves:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Hammond Valve.

e. Honeywell Braukmann.

f. Jamesbury, Inc.

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Brass or bronze body with full-port, chrome-plated bronze ball; seats; and 400-psig minimum CWP rating and blowout-proof stem.

## 2.04 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Manufacturers:

1. Crane Co.; Crane Valve Group; Flowseal.

2. General Signal; DeZurik Unit.

3. Grinnell Corporation.

4. Jamesbury, Inc.

B. High-performance Butterfly Valves, General: MSS SP-68.

C. Flangeless, Class 150, High-Performance Butterfly Valves: Wafer type.

D. Single-Flange, Class 150, High-Performance Butterfly Valves: Wafer type.

2.05 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze, Horizontal Lift Check Valves with Metal Disc:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Stockham Div.

2. Bronze, Vertical Lift Check Valves with Metal Disc:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

3. Bronze, Swing Check Valves with Metal Disc:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

B. Bronze Check Valves, General: MSS SP-80.

C. Class 150, Bronze, Horizontal Lift Check Valves: Bronze body with bronze disc and seat.

D. Class 150, Bronze, Vertical Lift Check Valves: Bronze body with bronze disc and seat.

E. Class 150, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

2.06 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:

1. Type I, Gray-Iron Swing Check Valves with Metal Seats:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

2. Grooved-End, Ductile-Iron Swing Check Valves:

a. Grinnell Corporation.

b. Victaulic Co. of America.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Class 125, gray-iron, swing check valves with metal seats.

D. 175-psig (1207-kPa) CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends.

2.07 SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Manufacturers:

1. Globe Lift-Disc Check Valves:

a. Grinnell Corporation.

b. Hammond Valve.

c. Milwaukee Valve Company.

2. Threaded Lift-Disc Check Valves:

a. Grinnell Corporation.

b. Milwaukee Valve Company.

c. Mueller Steam Specialty.

B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.

C. Class 125, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends.

D. Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.

E. Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends.

2.08 BRONZE GATE VALVES

A. Manufacturers:

1. Bronze, Rising-Stem, Solid-Wedge Gate Valves:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

B. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

2.09 BRONZE GLOBE VALVES

A. Manufacturers:

1. Bronze Globe Valves with Metal Disc:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

2. Bronze Globe Valves with Renewable Seat and Metal Disc:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Class 150, Bronze Globe Valves: Bronze body with bronze disc and union-ring bonnet.

D. Class 150, Bronze Globe Valves: Bronze body with bronze disc and renewable seat. Include union-ring bonnet.

2.10 CAST-IRON GLOBE VALVES

A. Manufacturers:

1. Cast-Iron Globe Valves with Metal Seats:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Div.

d. Grinnell Corporation.

e. Hammond Valve.

f. Milwaukee Valve Company.

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Class 125, Cast-Iron Globe Valves: Gray-iron body with bronze seats.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball or butterfly.

2. Throttling Service: Ball, butterfly, or globe valves.

3. Pump Discharge: Spring-loaded, lift-disc check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Heating Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 (DN 50) and Smaller: Two-piece, 400-psig (2760-kPa) CWP rating, copper alloy.

2. Ball Valves, NPS 2-1/2 (DN 65) to NPS 4: Class 150, ferrous alloy.

3. Lift Check Valves, NPS 2 (DN 50) and Smaller: Class 150, vertical, bronze.

4. Swing Check Valves, NPS 2 (DN 50) and Smaller: Class 150 bronze.

5. Swing Check Valves, NPS 2-1/2 (DN 65) and Larger: Class 125, gray iron.

6. Spring-Loaded, Lift-Disc Check Valves, NPS 2 (DN 50) and Smaller: Class 150.

7. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 (DN 65) and Larger: Class 125, cast iron.

8. Globe Valves, NPS 2 (DN 50) and Smaller: Class 150, bronze.

9. Globe Valves, NPS 2-1/2 (DN 65) and Larger: Class 125, bronze-mounted cast

D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends heating hot water.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded ends.

3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded ends.

6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

7. For Grooved-End, Steel Piping: Valve ends may be grooved. Do not use for steam or steam condensate piping.

## 3.03 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.

3. Lift Check Valves: With stem upright and plumb.

## 3.04 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.05 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
3. Division 23 Section " Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
4. Division 23 Section " Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
5. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment.

1.5 SUPPLEMENTARY STEEL

A. Furnish supplementary steel as required for proper installation, mounting and support of HVAC work.

B. Connect supplementary steel firmly to building construction in an acceptable manner.

C. Determine type and size of supplementary steel. Supplementary steel shall be of sufficient strength and size to allow a minimum deflection of 1/360 of the span and in conformance with manufacturer's requirements of loading.

D. Install supplementary steel in a neat and workmanlike manner parallel to walls, floors and ceiling construction.

E. All supplementary steel and channel supports shall be submitted to the structural engineer for review

1.6 EXPANSION ANCHORS

A. Provide smooth wall, non-self-drilling internal plug expansion type anchors constructed of AISC 12L14 steel and zinc plated in accordance with Fed. Spec. QQ-A-325 Type 1, Class 3.

B. Do no exceed 1/4 of average values for a specific anchor size using 2,000 psig (13,800 kpa) concrete only for maximum working load.

C. Provide spacing and install anchors in accordance with manufacturer's recommendations.

1.7 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Fiberglass pipe hangers.
3. Thermal-hanger shield inserts.
4. Powder-actuated fastener systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Fiberglass strut systems. Include Product Data for components.
4. Pipe stands. Include Product Data for components.
5. Equipment supports.

C. Submit to the structural engineer:

1. Details of all proposed methods of attachment to the building structure for all hangers and supports.
2. All forces and weights that will be imposed on the building structure by the hangers and supports.

D. Welding certificates.

## 1.8 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.3, "Structural Welding Code--Sheet Steel."
4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
5. ASME Boiler and Pressure Vessel Code: Section IX.

C. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

## 2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. B-Line Systems, Inc.; a division of Cooper Industries.
3. Carpenter & Paterson, Inc.
4. Empire Industries, Inc.
5. Globe Pipe Hanger Products, Inc.
6. Grinnell Corp.
7. GS Metals Corp.
8. National Pipe Hanger Corporation.
9. PHD Manufacturing, Inc.
10. Piping Technology & Products, Inc.
11. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

## 2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

## 2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.

4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

## 2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

## 2.6 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:

a. Hilti, Inc.
b. ITW Ramset/Red Head.
c. Masterset Fastening Systems, Inc.
d. MKT Fastening, LLC.
e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. Empire Industries, Inc.
c. Hilti, Inc.
d. ITW Ramset/Red Head.
e. MKT Fastening, LLC.
f. Powers Fasteners.

## 2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:

a. ERICO/Michigan Hanger Co.
b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:

a. MIRO Industries.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:

a. ERICO/Michigan Hanger Co.
b. MIRO Industries.
c. Portable Pipe Hangers.

2. Base: Plastic or Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:

a. Portable Pipe Hangers.

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

## 2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

## 2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

# PART 3 - EXECUTION

## 3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN 100 to DN 400), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN 15 to DN 50).
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.

b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

## 3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [**NPS 2-1/2 (DN 65)**] <**Insert other**> and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

## 3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

## 3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Elastomeric hangers.
2. Spring hangers.
3. Spring hangers with vertical-limit stops.
4. Pipe riser resilient supports.
5. Resilient pipe guides.
6. Freestanding and restrained air-mounting system.
7. Restraining braces and cables.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

C. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

D. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

E. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

F. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

## 2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. The product indicated on Drawings or a comparable product by one of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.
10. <**Insert manufacturer's name**>.

C. Restraint Cables: [**ASTM A 603 galvanized**] [**ASTM A 492 stainless**]-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

D. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

F. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

## 2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

## 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Hydronic Piping" for piping flexible connections.

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

## 3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

## 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration And Training."

END OF SECTION 230548

SECTION 230548 — MECHANICAL VIBRATION ISOLATION AND SEISMIC RESTRAINT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. It is the objective of this Specification to provide the necessary design requirements for the control of excessive noise and vibration in the buildings due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit. It is also the objective of this specification to provide the design criteria for seismic restraints for all isolated and non-isolated equipment.

B. Work in this section includes the providing of labor, materials, equipment and services necessary for a complete and safe installation in of vibration isolation systems and seismic restraints for every mechanical system including piping and ductwork within and on the roof of the building, complete, as shown and specified per the contract documents and all applicable codes and authorities having jurisdiction.

C. The work of this section includes, but is not limited to the following:

1. Vibration isolation elements for piping and equipment.

2. Equipment isolation bases.

3. Piping flexible connections.

4. Seismic restraints for isolated and non-isolated piping, tanks, stacks, ductwork, VAV boxes, and equipment.

D. Related Sections:

1. All Division 23000 Sections as issued for this project under "Mechanical/HVAC".

E. Seismic restraints:

1. All equipment, piping and ductwork shall be adequately restrained to resist seismic forces. This specification is in addition to the specified vibration isolation for this project. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest issue of the state and local codes and other authorities having jurisdiction.

2. Anchor bolt calculations, signed and stamped by a registered Professional Engineer, shall be submitted showing adequacy of the bolt sizing and type. Calculations shall include anchor

embedment, minimum edge distance and minimum center distance. The design lateral forces shall be distributed in proportion to the mass distribution of the equipment. Calculations shall be furnished for anchors on restraint devices, cables, isolators and on rigid mounted equipment. The seismic designer must perform final jobsite inspection to verify anchor installation.

3. Contractor shall supply all supplemental steel required for all equipment, ductwork and piping including roof mounted equipment.

4. All isolators and equipment shall meet OSHPD requirements and contain approval from OSHPD.

F. This specification shall be supplemented by all local codes and ordinance which shall take precedence in the event of the existence of any conflict between same and this specification. Where methods or materials specified are equivalent to the code requirements specified, comply with the specified requirements.

1.3 SUBMITTALS

A. In addition to the requirements of the section on Mechanical General Provisions, the submittal material shall include thirteen (13) copies of descriptive data for all products and materials including, but not limited to, the following:

1. Descriptive Data:
   a. Catalog cuts and data sheets on specific vibration isolators and seismic restraints to be utilized showing compliance with the specifications.
   b. An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawings showing seismic restraints, base and construction where applicable.
   c. An itemized list of non-isolated equipment, piping, and ductwork to be seismically restrained.
   d. Seismic restraint calculations.
   e. Riser supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   f. Structural or civil engineer's stamp verifying design and calculations for seismic restraining systems used.

2. Shop Drawings:
   a. Drawings showing equipment base constructions for each machine, including dimensions, structural member sizes and support point locations.
   b. Drawings showing methods of suspension, support guides for piping and ductwork.
   c. Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.
   d. Concrete and steel details for bases, including anchor bolt locations.
   e. Number and location of seismic restraints and anchors for each piece of equipment and of ductwork and piping.
   f. Specific details of restraints, including anchor bolts for mounting and maximum loading at each location for each piece of equipment and lengths of ductwork and piping.

1.4 CODE AND REFERENCE STANDARD REQUIREMENTS

A. All equipment supplied under this specification shall conform in all respects to the rules and regulations of:

1. **International Building Code (IBC) Section 1613.6**

2. **ASCE 7-05, section 13.6**

3. SMACNA "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems." 1982

4. 2003 ASHRAE GUIDE, Chapter 47, and Chapter 54

5. All applicable state and local codes and authorities having jurisdiction.

6. American Society for Testing and Materials:
   a. ASTM A 36/a 36M-96: Specification for Carbon Structural Steel.
   b. ASTM E 488-96: Test Methods for Strength of Anchors in Concrete and Masonry Elements.

7. American Welding Society:
   a. ASW D1.1-98: Structural Welding Code – Steel.

1.5 QUALITY ASSURANCE

A. All vibration isolation and seismic restraint devices shall be the product of a single manufacturer. Products of other manufacturer's are acceptable provided that their systems comply with the design intent for system performance, static deflection and structural design of the base manufacturer.

B. Vibration isolation firms having a minimum ten years experience designing and supervising the installation of vibration isolation and seismic restraint systems shall be qualified to provide the materials and installation required by this section. Project listings shall be provided including geographical location and a reference contact.

C. The installation of all vibration isolation units, and associated seismic restraints, hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative.The isolation manufacturer is to send a letter stating that they have inspected all of the vibration isolation units installed and they are installed properly and operating.

D. Substitution of internally isolated mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above acceleration loads are certified in writing by the equipment manufacturer and stamped and sealed by a licensed civil or structural engineer.

E. Purchased and/or fabricated equipment must be designed to safely accept external forces of 1.0 g load in any direction for all rigidly and resiliently supported equipment, piping and ductwork without failure and permanent displacement of the equipment. Life safety equipment such as fire pumps, smoke exhaust fans, emergency generators and other life safety designated equipment must be capable of accepting external forces of up to 1.5 g in any direction without permanent displacement or failure of the equipment.

F. Standards: If any item in this specification as furnished by the contractor is manufactured in a location which does not certify the referenced standards as defined in paragraph 1.4 of this

specification, the contractor is to pay the owner for **all** expenses incurred by the owner for an outside testing company top confirm such compliances.

G. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver each item as a factory-assembled unit with protective crating and covering.

B. Store in a dry location.

C. Provide disassembly and re-assembly as required to accommodate rigging and shipping.

D. Comply with the manufacturer's written rigging and installation instructions for unloading, transporting and setting in final location.

E. All equipment with shaft bearings (pump, fans, etc..) must have the shaft rotated every 2 weeks and the equipment must be stared inside.

1.7 SUBSTITUTIONS

A. Any proposed substitution must be submitted at the time the bid is submitted. No substitute material or manufacturer of equipment shall be permitted without a formal written submittal to the engineer which includes all dimensional, performance and material specifications and is approved in writing by the engineer. Any changes in layout or design brought about by the use of a substitution shall be submitted to the engineer fully designed for review in conjunction with the submittal of the alternate. Any substitutions must be submitted with an explanation why a substitution is being proposed. If the substitute is being proposed for financial reasons the associated credit must be simultaneously submitted.

B. Final acceptance or rejection of any substitution is subject to the Owner’s review.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Coordinate with the architect and structural engineer for concrete, reinforcement, and formwork requirements.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following are approved manufacturers, provided their systems strictly comply with the design intent for performance, deflection and structural capacity of this specification.

1. Mason Industries, Inc., Hauppauge, NY

2. Vibration Mountings & Controls, Inc., Bloomingdale, NJ

3. Kinetics Noise Control, Dublin, OH

4. Vibration Eliminator Co., Inc., Capiague, NY

5. Amber Booth, Houston, TX

2.2 DESCRIPTION

A. All vibration isolators shall have either known undeflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.

B. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.

C. Where spring isolation systems are described in the following specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the springs remain parallel. The minimum deflection from loaded operating height to spring solid height shall be 50% of the rated static deflection of the spring.

D. Where neoprene-in-shear isolation systems are described in the following specifications, the mounting assemblies shall utilize bare neoprene elements with unit type design molded in oil resistant neoprene. The neoprene shall be compounded to meet the following:

1. Shore hardness of 35 to 65 $\pm$5, after minimum aging of 20 days or corresponding oven-aging.

2. Minimum tensile strength of 2000 PSI.

3. Minimum elongation of 300 %.

4. Maximum compression at 25 % of original deflection.

E. The isolator ratio of lateral to vertical stiffness shall not be less than 0.9 nor more than 1.5.

F. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than $\pm$10%.

G. All mounting systems, including seismic restraints, exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be powder coated and neoprene coated. Nuts and bolts shall be cadmium plated.

H. All roof-mounted isolators shall be bolted or welded to building steel and anchored to the concrete deck to resist 110 mph wind loads.

## 2.3 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation and seismic restraint equipment shall have the following responsibilities:

1. Determine vibration isolation and seismic restraint sizes and locations.

2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.

3. Guarantee specified isolation system deflection.

4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.

## 2.4 VIBRATION ISOLATORS

A. Type A: Bare spring isolators shall incorporate the following:

1. Minimum 1/4" (6 mm) thick neoprene acoustical base pad on underside, unless designated otherwise.

2. Non-resonant with equipment forcing frequencies or support structure natural frequencies.

3. Requires seismic restraint type II

4. Spring isolators to be Mason Type SLF, or as approved.

B. Type B: Spring isolators shall be same as Type A, except:

1. Provide built-in vertical limit stops with minimum 1/4" (6 mm) clearance under normal operation.

2. Tapped holes in top plate for bolting to equipment.

3. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.

4. Shall incorporate snubbing restraint in all directions. Cast or aluminum housings are unacceptable. System to be field bolted or welded to deck with ability to resist forces of 1.5 g acceleration.

5. Mason Type SLR, or as approved.

C. Type C: Spring hanger rod isolators shall incorporate the following:

1. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.

2. Steel retainer box encasing the spring and neoprene cup.

3. Provide sufficient clearance between retainer box and spring hanger rod to permit minimum 15 degree allowable rod misalignment in any direction, total 30 degrees.

4. Requires seismic restraint type III

5. Mason Type TPC-30N, or as approved.

6. Where operating weight differs from installed weight, provide built-in adjustable limit stops to prevent equipment rising when weight is removed. Stops shall not be in contact during normal operation.

D. Type D: Elastomer Mounting Types/Elastomer Isolators, shall incorporate the following:

1. Bolt holes for bolting to equipment base.

2. Bottom steel plates for bolting or welding to sub-base as required.

3. Unit type design molded in oil-resistant neoprene.

4. Encased in ductile steel or iron casing and capable of withstanding external forces of up to 1.5 g. System to be field bolted or welded to deck with ability to resist forces of 1.5 g.

5. Mason Type ND isolation BR, RBA or as approved.

E. Type E: Elastomer hanger rod isolators shall incorporate the following:

1. Molded unit type neoprene element with projecting bushing lining rod clearance hole.

2. Neoprene element to be minimum 1 3/4" (45 mm) thick.

3. Steel retainer box encasing neoprene mounting.

4. Clearance between mounting hanger rod and neoprene bushing shall be minimum 1/8" (3 mm).

5. Requires seismic restraint type III.

6. Mason Type HD, or as approved.

F. Type F: Combination spring/elastomer hanger rod isolators to incorporate the following:

1. Spring and neoprene isolator elements in a steel box retainer.

2. Other characteristics of steel box retainer and hanger rod swing as described for Type C isolators.

3. delete seismic reference if seismic is not part of this project.

4. Requires seismic restraint type III

5. Mason Type TPC-30N, or as approved.

G. Type G: Pad type elastomer mountings to incorporate the following:

1. 0.750" (19 mm) minimum thickness.

2. 50 psi (345 KN/m2) maximum loading.

3. Ribbed or waffled design.

4. 0.10" (2.5 mm) deflection per pad thickness.

5. 1/16" (1.6 mm) galvanized steel plate between multiple layers of pad thickness.

6. Suitable bearing plate to distribute load.

7. delete seismic reference if seismic is not part of this project.

8. Requires seismic restraint type II or III as installation requires.

9. Mason Type Super W, or as approved.

H. Type H: Pad type elastomer mountings to incorporate the following:

1. Laminated canvas duck and neoprene.

2. Maximum loading 1000 psi (6900 KN/m2).

3. Suitable bearing plate to distribute load.

4. Minimum thickness, 2" (12 mm).

5. delete seismic reference if seismic is not part of this project.

6. Requires seismic restraint type II or III as installation requires.

7. Mason Type HL, or as approved.

I. Type I: Air Air Mounts: Freestanding, single or multiple, compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.

2. Maximum Natural Frequency: 3 Hz.

3. Operating Pressure Range: 25 to 100 psig(172 to 690 kPa).

4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.

5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch(3 mm).

6. delete seismic reference if seismic is not part of this project.

7. Requires seismic restraint type II

J. Restrained Air Mounts: Housed compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.

2. Maximum Natural Frequency: 3 Hz.

3. Operating Pressure Range: 25 to 100 psig(172 to 690 kPa).

4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.

5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch(3 mm).

6. delete seismic reference if seismic is not part of this project.

7. Requires seismic restraint type II

K. Curb Mounted Base, Type B-3

1. Curb mounted rooftop equipment shall be mounted on spring isolation curbs that directly sit on roof construction and are flashed and incorporated into roof's membrane waterproofing system.

2. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal.

3. All spring mounts shall be as Isolator Type B.

4. Curb and spring mounting shall be capable of withstanding 110mph wind and 1.5 g seismic loads.

5. Curbs shall be Mason Type CMAB or RSC (depending on deflection required), or approved equal.

2.5 FLEXIBLE CONNECTORS

A. Elastomer Type FC-1

1. Manufactured of nylon tire cord and EPDM, both molded and cured with hydraulic presses.

2. Straight connectors to have two spheres reinforced with a molded-in external ductile iron ring between spheres.

3. Elbow shall be long radius reducing type.

4. Rated 250 psi. (1,700 KN/$m^2$) at 170□F (77□C). Dropping in a straight line to 170 psi. (1,200 KN/$m^2$) at 250□F (120□C) for sizes 1-1/2" to 12" (38 to 305 mm), elbows. Elbows shall be rated no less than 90% of straight connections.

5. Sizes 10" (254 mm) and 12" (305 mm) to employ control cables with neoprene end fittings isolated from anchor plates by means of 2" (12 mm) bridge bearing neoprene bushings.

6. Minimum safety factor of 4 to 1 at maximum pressure ratings.

7. Submittals to include test reports, projected life, replacement interval, compression and elongation limits.

8. Mason Types SuperFlex MFNEC, MFLRR, MFTFU, MFTNC, MFTCR, or as approved.

B. Flexible Stainless Hose, Type FC-2

1. Braided flexible metal hose.

2. 2" (50 mm) pipe size and smaller with male nipple fittings.

3. 2-1/2" (62.5 mm) and larger pipe size with fixed steel flanges.

4. Suitable for operating pressure with 4 to 1 minimum safety factor.

5. Length as shown on drawings.

6. Mason Type BSS, or as approved.

C. Unbraided Exhaust Hose, Type FC-3

1. Low pressure stainless steel angularly corrugated.

2. Fitted with flanged ends.

3. Maximum temperature 1500□F (815□C)

4. Mason Type SDL-RF, or as approved.

2.6 SEISMIC RESTRAINTS

A. All seismic restraints for mechanical equipment shall be capable of safely accepting 1.0 g (1.5 g for designated life safety equipment) external forces without failure, and shall maintain equipment, piping, duct and pressure reducing boxes in a captive position. Seismic restraints shall not short circuit isolation systems or transmit objectionable vibration or noise, and shall be Provided on all equipment as scheduled on drawings.

B. Submit calculations by a licensed Structural or Civil Engineer substantiating that all equipment mountings and foundations and their seismic restraints can safely accept external forces of 1.0 g load for all rigidly and resiliently supported equipment, piping, and ductwork (1.5 g load for all life safety equipment) without failure and permanent displacement. Restrain all resiliently mounted piping and ductwork with cable sway bracing by Mason Industries, or approved equal.

C. Seismic Restraint Types

1. Seismic Restraint, Type I
   a. Shall comply with general characteristics of spring isolators.
   b. Shall have vertical restraints and are capable of supporting equipment at fixed elevation during equipment erection.
   c. Shall incorporate seismic snubbing restraint in all directions at specified acceleration loadings.
   d. System to be field bolted to structure with minimum capability to withstand external forces of 1.5 g.
   e. Mason Type SSLR, or as approved

2. Seismic Restraint, Type II
   a. Each corner or side seismic restraint shall incorporate minimum 5/8" (16 mm) thick pad limit stops. Restraints shall be made of plate, structural members or square metal tubing in a welded assembly, incorporating resilient pads. Angle bumpers are not acceptable. System to be field bolted to deck with 1.5 g acceleration capacity.

b. Seismic spring mountings as described above are an acceptable alternative providing all seismic loading requirements are met.
c. Mason Industries Type Z-1011, Type Z-1225, or as approved.

3. Seismic Restraint, Type III
a. Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable fastening to equipment and structure. System to be field bolted to deck or overhead structural members or deck with aircraft cable and clamps as per SMACNA guidelines.

## PART 3 - EXECUTION

### 3.1 GENERAL VIBRATION ISOLATION REQUIREMENTS

A. Install in accordance with manufacturer's written instructions. Vibration isolators must not cause any change of position of equipment or piping resulting in piping stresses or misalignment.

B. Mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators as scheduled on the drawings or within these specifications.

C. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation systems herein specified.

D. Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment.

E. The contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in this Specification. Building includes, but is not limited to, slabs, beams, columns, studs and walls.

F. Isolation mounting deflection shall be (minimum) as specified or scheduled on drawings.

G. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

H. Bring to the Architect's attention, prior to installation, any conflicts with other trades which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

I. Bring to the Architect's attention any discrepancies between the specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the contractor's expense.

J. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.

K. Correct, at no additional cost, all installations which are deemed defective in workmanship or materials.

3.2 EQUIPMENT ISOLATION

A. Mount floor mounted equipment on 4" (100 mm) high concrete housekeeping pads over complete floor area of equipment. Mount vibration isolating devices and related inertia blocks on concrete pad. Key housekeeping pads with hair pins, as required, to be integral with structural slab. Provide approved seismic restraint anchor plates flush with top of housekeeping pad. Concrete work specified in Division 3.

B. Each fan and motor assembly shall be supported on a single structural steel frame. Flexible duct connections shall be provided at inlet and discharge of fan.

C. The machine to be isolated shall be supported by a structural steel frame or concrete inertia base.

D. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.

E. The minimum operating clearance between the equipment frame or rigid steel base frame and the housekeeping pad or floor shall be 1" (25 mm). Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 2" (50 mm).

F. The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.

G. The isolators shall be installed without raising the machine and frame assembly.

H. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.

I. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.

J. Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4" (6 mm).

K. Provide flexible connections between all fans and ductwork. Refer to duct accessories section.

L. When operating weight differs from installed weight, provide built-in limit stops to prevent equipment from rising when weight is removed. Stops shall **not** be in contact during normal operation.

M. Additional Requirements

1. Diagonal thrust restraint shall be as described for Type C hanger with the same deflection as specified for the spring mountings. The spring element shall be designed so it can be pre-set for thrust and adjusted to allow for a maximum of 1/4" (6 mm) movement at start and stop. Thrust restraints shall be attached at the centerline of thrust. Restraint shall be Mason Type WB, or as approved.

2. All piping and ductwork to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain 3/4" to 1 1/4" (20 to 32 mm) clearance around the outside surfaces. This clearance space shall be tightly packed with fiberglass (except in cases of fire smoke dampers in ducts), and caulked airtight after installation of piping or ductwork.

3. HVAC piping vertical risers larger than 2" (50 mm) in diameter shall be isolated from the building structure by means of noise and vibration isolation guides and supports.

4. Isolators shall be installed with the isolator hanger box attached to, or hung as close as possible to, the structure. Hanger rods shall be aligned to clear the hanger box.

5. Isolators shall be suspended from substantial structural members, not from slab diaphragm unless specifically permitted.

6. Structural steel for cooling tower or other equipment must support the equipment without excessive deflection of the steel. The structural steel support shall not be resonant with the isolation system resonant frequencies or the driving frequencies of the supported equipment.

## 3.3 PIPING AND BOILER BREECHING ISOLATORS

A. All piping and boiler breeching, except fire standpipe systems, are included under this Section.

B. Installation:

1. Isolate piping and boiler breeching outside of shafts as follows:

2. All piping 2" (50 mm) and over located in mechanical equipment rooms, and for a minimum of fifty (50) feet (15 m) or 100 pipe diameters, whichever is greater, from connection to vibrating mechanical or electrical equipment, shall be isolated from the building structure by means of noise and vibration isolation hangers, Type F.

3. Horizontal suspended pipe 2" (50 mm) and smaller and all steam piping shall be suspended by Type E isolator with a minimum 3/8" (9.5 mm) deflection. Water pipe larger than 2" (50 mm) shall be supported by Type F isolator with a minimum 1" (25 mm), or same static deflection as isolated equipment to which pipe connects, whichever is greater.

4. Horizontal pipe floor supported at slab shall be supported via Type B, with a minimum static deflection of 1" (25 mm) or same deflection as isolated equipment to which pipe connects, whichever is the greater.

5. Vertical riser pipe supports shall utilize Type H.

6. Vertical riser guides, if required, shall avoid direct contact of piping with building.

7. Pipe anchors, where required, shall utilize resilient pipe anchors, Mason Industries Type ADA, or equivalent, to avoid direct contact of piping with building.

8. Pipe sway braces, where required, shall utilize two (2) neoprene elements (Type G or H to accommodate tension and compression forces).

9. Pipe extension and alignment connectors: Provide connectors at riser takeoffs, cooling and heating coils, and elsewhere as required, to accommodate thermal expansion and misalignment.

10. Adjust, as required, all isolators to eliminate all contact of the isolated rod with the hanger rod box retainer or short circuiting of the spring.

C. Domestic Water System Isolation :

1. Support all domestic water piping in horizontal and vertical runs with a resilient wrapping or clamp system employing a resilient element of wool, felt, neoprene, or other suitable material; "Trisolators" by Semco or P.R. Isolators by Potter-Roemer, or as approved.

2. All domestic water piping, size 2" (50 mm) and larger within the building shall be isolated as follows:
   a. Provide Type F hanger rod isolators with a minimum static deflection of 1" (25 mm) or as scheduled.
   b. Provide Type B isolators with 1" (25 mm) static deflection, or as scheduled.
   c. Support water piping in shafts and floor supports` entering shaft with Type G isolators or Type H pad to prevent direct contact of piping with building structure.
   d. Guide and anchor piping in shafts, as required, with approved mounting designs incorporating Type H pad to prevent direct contact of pipe with building structure.

D. Isolator Position:

1. Close to building structure.

2. Between building structure and supplementary steel if required.

3. Suspend isolators from rigid and massive support points.

4. All supplementary steel to be sized for a maximum deflection of 0.08 inches (2 mm) at center span.

3.4 GENERAL SEISMIC RESTRAINT REQUIREMENT

A. All equipment whether isolated or not shall be bolted to structure to allow for minimum 1.0 g of acceleration (1.5 g for life safety equipment). Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and stamped and sealed by a civil or structural engineer.

B. Position all corner or side seismic restraints with equipment at operating weight for proper operation clearance and weld or bolt seismic restraint to seismic anchor plates in housekeeping pad. Install equipment with flexibility in wiring connection. Verify all installed isolators and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit startup equipment lateral motion to 1/4 inch. Prior to startup, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.

C. All suspended equipment, whether isolated or not, shall be seismically restrained at four points with Type III cable restraints.

D. Install seismic restraining system Type III taut for overhead suspended unisolated equipment, piping or ductwork, and slack with 2" (12 mm) cable deflection for isolated systems.

E. Seismically restrain all piping and ductwork with center bracing or Type III restraining system in accordance with SMACNA guidelines to comply with the UBC 1988 State of California with 1989 Amendments as outlined below:

1. All schedule 10, 20, or 40 piping shall be welded or laterally braced at 40 foot (12 m) intervals and at turns of more than 4 feet (1.2 m). Longitudinally bracing shall be supplied at 80 foot intervals. No-hub piping shall be braced at 10 foot intervals or at 40 foot intervals if 1.5 g rated couplings are used.

2. Ductwork to be braced every 30 feet (9 m) and at every turn and duct run ends. Longitudinal bracing to be provided at 60 foot intervals.

F. Seismic restraints are not required for the following:

1. Gas piping less than 1" (25 mm) internal diameter.

2. Piping in boiler and MER room that is less than 1 1/4" (32 mm) internal diameter. Less than 1 inch for fuel oil piping.

3. All other piping and electrical conduit less than 2" (64 mm) internal diameter.

4. All rectangular ducts less than 6 sq. ft. (0.56 $m^2$) in cross sectional area.

5. All round ducts less than 28" (710 m) in diameter.

6. All piping suspended by individual hangers 12" (305 mm) in length or less from the top of the pipe to the bottom of the support for the hanger.

7. All ducts suspended by hangers 12" (305 mm) or less in length from the point of the attachment to the duct to the bottom of the support for the hanger.

G. Chimneys and stacks passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps or approved vibration isolation systems with seismic restraints.

H. Chimneys and stacks running horizontally to be braced every 30 ft (9 m) with Type III restraining system.

I. Where base anchoring is insufficient to resist seismic forces, supplementary restraining such as seismic restraint system Type III shall be used above system's center of gravity to suitably resist "g" force levels. Vertically mounted tanks may require this additional restraint.

J. For overhead supported equipment, overstress of the building structure must not occur. Bracing may occur from:

1. upper flanges of structural beams;

2. upper truss chords in bar joist construction at the panel points;

3. cast-in-place inserts or drilled and shielded inserts in concrete structures suitably located away from edges.

K. Each seismic restraint and snubbing device shall be installed after equipment is installed and fully operational. Each isolation mounting incorporating seismic restraint shall be adjusted to provide the minimum operating clearance in all directions to permit the operation of the equipment without objectionable noise or vibration to any part of the building structure. The operating clearance for equipment seismic restraints shall not be greater than 1/4" (6 mm). Seismic restraints must not result in short-circuiting of isolated equipment.

L. Pipe risers through cored holes in structure require no additional seismic bracing. (Cored hole diameter to be a maximum of 2 inches larger than pipe outer diameter).

3.5 INSPECTION

A. On completion of installation of all vibration isolation and seismic restraint devices herein specified, the local representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representatives final report, indicating all isolation reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

B. **A**ir-Mounting System Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping connections. Report results in writing**.**

1. Isolator seismic-restraint clearance.

2. Isolator deflection.

3. Snubber minimum clearances.

4. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

5. Operational Test: Test the compressed-air leveling system. Remove malfunctioning units, replace with new units, and retest.

6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 VIBRATION TESTING

A. Owner reserves the right to require vibration testing for all new rotating pieces of equipment installed under this contract including pumps and fans. Vibration testing will be performed after the equipment is installed, aligned, dynamically balanced and commissioned. The mechanical contractor shall correct any deficiencies found with the new equipment as identified in the vibration analysis report. The vibration testing shall be as follows:

1. Equipment Vibration testing shall be performed by a certified vibration consultant. A report shall be provided indicating all of the pieces of equipment tested, the results of the tests and any deficiencies found.

2. Vibration allowances shall be as per the latest ASHRAE standard for rotating equipment (ASHRAE 2000 Systems and Equipment), as defined here:

3. Vibration shall not exceed 0.20 inches per second (0.20 in/sec), peak value throughout the operating range of the piece of rotating equipment. (If connected to a VFD.)

4. Measurements for all equipment, at each point shall be taken at each axis (3 axis) throughout the entire operating range of the equipment. (If connected to a VFD.)

5. The test for equipment connected and driven by a Variable Frequency Drive shall include natural (critical) speed testing. Measurements shall be taken throughout the operating range of the equipment starting from a complete stop, ramping slowly up to maximum speed, and pausing briefly at the natural frequencies of the equipment/VFD (15, 30, 45 and 60 Hz) during the test.

6. Tests for any piece of equipment not driven by a VFD shall be at their normal operating speed, under normal operating conditions.

## 3.7 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

## 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 23 Section HVAC General Provisions or to Division 1 Section "[**Closeout Procedures**] [**Demonstration and Training**]."

## 3.9 VIBRATION ISOLATION AND SEISMIC RESTRAINT SCHEDULE

| | | | | | |
|---|---|---|---|---|---|
| **Centrifugal Fans** | | | | | |
| Up to 22 in. diameter | All | All | B-1 | A or C | .75 |
| 24 in. diameter and up | Up to 40 | Up to 300 | B-1 | A or C | 3.50 |
| | | 300 to 500 | B-1 | A or C | 2.50 |
| | | 501 & up | B-1 | A or C | 1.5 |
| | 50 and up | Up to 300 | B-2 | A or C | 3.50 |
| | | 300 to 500 | B-2 | A or C | 2.50 |
| | | 501 & up | B-2 | A or C | 1.50 |
| **Propeller Fans** | | | | | |
| Wall-mounted | All | All | – | G | 0.25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Roof-mounted | | All | All | B-3 | B | 1.50 |
| | On Roof | All | All | – | B | 2.0 |
| | | | | | | |
| **Packaged Rooftop Equipment** | | All | All | See Reference Note No: 17 | | |
| | | | | | | |

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: [**Brass, 0.032-inch (0.8-mm)**] [**Stainless steel, 0.025-inch (0.64-mm)**] [**Aluminum, 0.032-inch (0.8-mm)**] [**or**] [**anodized aluminum, 0.032-inch (0.8-mm)**] minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [**1/16 inch (1.6 mm)**] [**1/8 inch (3.2 mm)**] <**Insert dimension**> thick, and having predrilled holes for attachment hardware.
2. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
3. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

## 2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches (38 mm) high.

## 2.3 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

C. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel [**rivets**] [**rivets or self-tapping screws**] [**self-tapping screws**].

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches (38 mm) high.

## 2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: [**Aluminum**] [**Brass**] [**Fiberboard**] [**Fiberboard or metal**] <**Insert material**>.
2. Stencil Paint: Exterior, gloss, [**alkyd enamel**] [**acrylic enamel**] <**Insert paint type**> black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, [**alkyd enamel**] [**acrylic enamel**] <**Insert paint type**> in colors according to ASME A13.1 unless otherwise indicated.

## 2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

1. Tag Material: [**Brass, 0.032-inch (0.8-mm)**] [**Stainless steel, 0.025-inch (0.64-mm)**] [**Aluminum, 0.032-inch (0.8-mm)**] [**or**] [**anodized aluminum, 0.032-inch (0.8-mm)**] minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass [**wire-link or beaded chain; or S-hook**] [**wire-link chain**] [**beaded chain**] [**S-hook**].

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

## 2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: [**3 by 5-1/4 inches (75 by 133 mm) minimum**] [**Approximately 4 by 7 inches (100 by 178 mm)**] <**Insert size**>.
2. Fasteners: [**Brass grommet and wire**] [**Reinforced grommet and wire or string**].
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

### 3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

### 3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "[**Interior Painting**] [**High-Performance Coatings**]."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels [**with painted, color-coded bands or rectangles**] [**, complying with ASME A13.1,**] on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of [**50 feet (15 m)**] <**Insert dimension**> along each run. Reduce intervals to [**25 feet (7.6 m)**] <**Insert dimension**> in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Chilled-Water Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

2. Condenser-Water Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

3. Heating Water Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

4. Refrigerant Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

5. Low-Pressure Steam Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

6. High-Pressure Steam Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

7. Steam Condensate Piping:

a. Background Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.
b. Letter Color: [**Black**] [**Blue**] [**Red**] [**White**] [**Yellow**] <**Insert color**>.

## 3.4 DUCT LABEL INSTALLATION

A. Install [**plastic-laminated**] [**self-adhesive**] duct labels with permanent adhesive on air ducts in the following color codes:

1. [**Blue**] <**Insert color**>: For cold-air supply ducts.
2. [**Yellow**] <**Insert color**>: For hot-air supply ducts.
3. [**Green**] <**Insert color**>: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of [**50 feet (15 m)**] <**Insert dimension**> in each space where ducts are exposed or concealed by removable ceiling system.

## 3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Chilled Water: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   b. Condenser Water: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   c. Refrigerant: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   d. Hot Water: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   e. Gas: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   f. Low-Pressure Steam: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   g. High-Pressure Steam: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.
   h. Steam Condensate: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**], [**round**] [**square**] <**Insert shape**>.

2. Valve-Tag Color:

   a. Chilled Water: [**Natural**] [**Green**] <**Insert color**>.
   b. Condenser Water: [**Natural**] [**Green**] <**Insert color**>.
   c. Refrigerant: [**Natural**] [**Green**] <**Insert color**>.
   d. Hot Water: [**Natural**] [**Green**] <**Insert color**>.
   e. Gas: [**Natural**] [**Yellow**] <**Insert color**>.
   f. Low-Pressure Steam: [**Natural**] [**Yellow**] <**Insert color**>.
   g. High-Pressure Steam: [**Natural**] [**Green**] <**Insert color**>.
   h. Steam Condensate: [**Natural**] [**Green**] <**Insert color**>.

3. Letter Color:

a. Chilled Water: [**Black**] [**White**] <**Insert color**>.
b. Condenser Water: [**Black**] [**White**] <**Insert color**>.
c. Refrigerant: [**Black**] [**White**] <**Insert color**>.
d. Hot Water: [**Black**] [**White**] <**Insert color**>.
e. Gas: [**Black**] [**White**] <**Insert color**>.
f. Low-Pressure Steam: [**Black**] [**White**] <**Insert color**>.
g. High-Pressure Steam: [**Black**] [**White**] <**Insert color**>.
h. Steam Condensate: [**Black**] [**White**] <**Insert color**>.

## 3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

a. Variable-air-volume systems.

2. Hydronic Piping Systems:

a. Constant-flow systems.

3. Reuse and testing of existing systems

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of systems or equipment.

S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

## 1.4 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by NEBB, or TABB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. The Contract Documents examination report.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in [**AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems**] [**NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification**]."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

## 3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

C. Pre-construction air and water testing

Engineer note: use if existing base building main ductwork or systems are being connected to.

1. `before starting work. Traverse main supply and return ducts before work to obtain total flow. Submit report to engineer immediately after completion of test

2. Measure flowrate of water (chilled, glycol, hot, condenser water) and differential pressure across risers or mains to space to determine flowrate, entering and differential pressure being provided..

## 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems"or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

## 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

## 3.5 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

B. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box.

1. If insufficient static pressure exists, increase the airflow at the fan.

C. Test and adjust the constant-volume mixing boxes as follows:

1. Verify both hot and cold operations by adjusting the thermostat and observing the air temperature and volume changes.
2. Verify sufficient inlet static pressure before making volume adjustments.
3. Adjust mixing box to indicated airflows within specified tolerances. Measure the airflow by Pitot-tube traverse readings, totaling the airflow of the outlets; or by measuring static pressure at mixing-box taps if provided by box manufacturer.

D. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box.

E. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume dual-duct systems, and adjust each mixing-box maximum- and minimum-airflow settings.

## 3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

## 3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

## 3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

## 3.9 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

## 3.10 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

## 3.11 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling unit number.
    b. Location and zone.

c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

G. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

H. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).

e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

## 3.12 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:

   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure sound levels at two locations.
   e. Measure space pressure of at least 10 percent of locations.
   f. Verify that balancing devices are marked with final balance position.
   g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:

a. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

B. Related Sections:

1. Division 23 Section "Common Works Results for HVAC."
2. Division 23 Section "Hydronic Piping."
3. Division 23 Section "Metal Ducts"

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

a. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
b. Sheet Form Insulation Materials: 12 inches (300 mm) square.
c. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
d. Sheet Jacket Materials: 12 inches (300 mm) square.
e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer, Provide a firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this project, whose work has resulted in construction with a record of successful in-service performance.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. Field quality-control reports.

## 1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.8 DEFINITIONS

A. Indoor Exposed: Indoor ducts, piping or equipment located in mechanical equipment rooms and in areas which will be visible without removing ceilings or opening access panels.

B. Indoor Concealed: Indoor ducts, piping or equipment which are not exposed to the weather.

C. Outdoor: All Ducts, piping or equipment which is exposed to the weather. All piping outdoors is considered to be exposed to the weather.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied. Refer to paragraph 3.14 for insulation schedules.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type **III with factory-applied FSK jacket**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Duct Wrap.
    d. Owens Corning; All-Service Duct Wrap.

G. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide the following:

    a. Johns Manville; HTB 23 Spin-Glas.
    b. Owens Corning; High Temperature Flexible Batt Insulations.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:

    a. CertainTeed Corp.; Commercial Board.
    b. Johns Manville; 800 Series Spin-Glas.
    c. Knauf Insulation; Insulation Board.
    d. Owens Corning; Fiberglas 700 Series.

I. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide the following:
    a. Johns Manville; 1000 Series Spin-Glas.
    b. Owens Corning; High Temperature Industrial Board Insulations.
    c. Roxul Inc.; Roxul RW.

J. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide the following available products that may be incorporated

   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000 Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

1. Products: Subject to compliance with requirements, provide the following :

   a. Knauf Insulation; Permawick Pipe Insulation.
   b. Owens Corning; VaporWick Pipe Insulation.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJcomplying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following :

   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.

## 2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, provide the following :

   a. Insulco, Division of MFS, Inc.; Triple I.

b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, provide the following :

a. P. K. Insulation Mfg. Co., Inc.; Thermal-V-Kote.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

1. Products: Subject to compliance with requirements, provide the following :

a. Insulco, Division of MFS, Inc.; SmoothKote.
b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
c. Rock Wool Manufacturing Company; Delta One Shot.

## 2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Products, Division of ITW; CP-97.
b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
c. Marathon Industries, Inc.; 290.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

C. Cellular-Glass, Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide the following:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide the following:

a. Dow Chemical Company (The); 739, Dow Silicone.
b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Red Devil, Inc.; Celulon Ultra Clear.
e. Speedline Corporation; Speedline Vinyl Adhesive.

## 2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Marathon Industries, Inc.; 590.
e. Mon-Eco Industries, Inc.; 55-40.
f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

## 2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, [**provide the following**] :

   a. Childers Products, Division of ITW; CP-52.
   b. Foster Products Corporation, H. B. Fuller Company; 81-42.
   c. Marathon Industries, Inc.; 130.
   d. Mon-Eco Industries, Inc.; 11-30.
   e. Vimasco Corporation; 136.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
4. Color: White.

## 2.6 SEALANTS

A. Joint Sealants:

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following :

   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following :

   a. Childers Products, Division of ITW; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.

## 2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, provide the following :

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, provide the following :

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

    a. Products: Subject to compliance with requirements, provide the following :

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, provide the following :

a. Vimasco Corporation; Elastafab 894.

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.

1. Products: Subject to compliance with requirements, provide the following :

a. Childers Products, Division of ITW; Chil-Glas No. 5.

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.

1. Products: Subject to compliance with requirements, provide the following :

a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

1. Products: Subject to compliance with requirements, provide the following :

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide the following :

a. Johns Manville; Zeston.

b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color as selected by Architect.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, provide the following :

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 2.5-mil- (0.063-mm-) thick Polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing Factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper .

d. Moisture Barrier for Outdoor Applications: 2.5-mil- (0.063-mm-) thick Polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, provide the following :

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard; Insulrap No Torch 125.

F. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with whitealuminum-foil facing.

1. Products: Subject to compliance with requirements, provide the following :

a. Polyguard; Alumaguard 60.

## 2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide the following :

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide the following :

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide the following :

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
   b. Compac Corp.; 130.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
   d. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide the following :

   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   b. Compac Corp.; 120.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.12 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide the following :

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing or closed seal.
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, provide the following :

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

a. Products: Subject to compliance with requirements, provide the following :

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide the following :

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.

2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: Copper- or zinc-coated, low carbon steel Aluminum, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide the following :

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide the following :

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: Copper- or zinc-coated, low carbon steel Aluminum, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide the following :

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide the following :

1) GEMCO.
2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. C & F Wire.
b. Childers Products.
c. PABCO Metals Corporation.
d. RPR Products, Inc.

## 2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type [**304**] [**316**] [**304 or 316**].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.

5. Handholes.
6. Cleanouts.

## 3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

1. Comply with requirements in Division 07 Section "Penetration Firestopping"irestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Pipe: Install insulation continuously through floor penetrations.

3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

## 3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

## 3.6 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching

staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

## 3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

## 3.8 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

## 3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
2. Inspect field-insulated equipment, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, three locations of threaded strainers, three locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

## 3.10 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, concealed return.
3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

## 3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

B. Concealed, round and flat-oval, return-air duct insulation (in unconditioned space) shall be the following:

1. Mineral-Fiber Blanket: 2 inches (51 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

C. Concealed, round and flat-oval, exhaust-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

D. Concealed, rectangular, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, return-air duct insulation (in unconditioned space )shall be the following:

1. Mineral-Fiber Blanket: 2 inches (51 mm) thick and 0.75-lb/cu. ft. nominal density.

F. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density

G. Concealed, supply-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

H. Concealed, return-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

I. Concealed, exhaust-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches (51 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

## 3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

## 3.13 INDOOR PIPING INSULATION SCHEDULE

A. Cold water Makeup, condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral Fiber Preformed pipe type I: 1 inch (25mm) thick

B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and below:

1. NPS 12 inches and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches (50 mm) thick.

2. NPS 14 inches and Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 3 inches (75 mm) thick.

## 3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

E. Piping, Concealed:

1. None.

F. Piping, Exposed:

1. None.
2. Aluminum, Smooth: 0.016 inch (0.41 mm) thick.

END OF SECTION 230700

SECTION 230900 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 DEFINITIONS

A. AHU: Air Handling Unit.

B. BMS: Building Management System.

C. CFM: Cubic Feet per Minute.

D. DDC: Direct-digital controls.

E. FAS: Fire Alarm System.

F. HVAC: Heating, Ventilating and Air Conditioning.

G. LCD: Liquid Crystal Display

H. PID: Proportional Integral Derivative.

I. VAV: Variable air volume.

J. VFD: Variable Frequency Drive.

1.4 SYSTEM DESCRIPTION

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories and software connected to distributed controllers operating in multiuser, multitasking environment on a network and programmed to control mechanical systems.

1.5 WORK INCLUDED

A. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all controllers and all input/output devices. Items of work included are as follows:

1. Provide a submittal that meets the requirements below for approval.

2. Coordinate installation schedule with the mechanical contractor and general contractor.

3. Provide installation of all panels and devices unless otherwise stated.

4. Provide power for panels and control devices from a source designated by the electrical contractor.

5. Provide all low voltage control wiring for the DDC system.

6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.

7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.

8. Provide testing, demonstration and training as specified below.

1.6 SUBMITTALS

A. One (1) submittal shall be provided for the project that includes information for controls for all systems being provided as part of the project. Partial submittals are not acceptable and shall not be reviewed by the Engineer.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

2. DDC System Hardware: Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels and operator interface equipment.

3. Control System Software: Include technical data for operating system software, operator interface, color graphics and other third-party applications.

4. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection. Submittal shall include the following as a minimum:

1. Schematic flow diagrams showing fans, coils, dampers, valves, instrumentation and control devices.

2. Wiring Diagrams: Power, signal and control wiring.

3. Architecture drawing including all communication wiring, network devices, etc. Indicate type of cabling and number of conductors.

4. Symbol and abbreviation list for control diagrams.

5. Points list including hardwired and software points.

6. Manufacturer’s technical cut sheets which include a table of contents and an associated sheet numbering system for all pages. Model number shall be circled or pointed with an arrow.

7. A complete bill of materials specific to each system detailing the equipment to be used, quantity, manufacturer, specific model number and tag number.

8. List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule and operator notations.

9. Details of control panel faces, including controls, instruments and labeling.

10. Schedule of valves including leakage, flow characteristics, GPM, design pressure drop, actual pressure drop, design CV, calculated CV, valve body pressure rating, and close-off pressure rating at a minimum.

11. All shop drawings used by field personnel for the installation of equipment shall bear an Engineer’s approval stamp.

12. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

D. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.

2. Keyboard illustrations and step-by-step procedures indexed for each operator function.

3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

4. Calibration records and list of set points.

E. The BMS Contractor shall correct any errors or omissions noted by the Owner and Engineer during review.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

C. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

E. All portions of the system must be designed, furnished, installed, commissioned and serviced by manufacturer-approved, factory-trained employees.

F. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

G. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

H. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

I. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

J. All system components shall be fault-tolerant. System shall include:

1. Satisfactory operation without damage at 110% and 90% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 100 hours and include local and remote system low battery indication.

K. The BMS contractor shall be regularly engaged in the installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of 10 years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.

2. A minimum of 10 years experience installing the control system of the manufacturer that is to be proposed.

3. Shall be a certified-to-install, direct representative of a control system manufacturer that has a minimum of 10 years experience producing control systems similar to that which is to be proposed.

4. A maintained service organization consisting of at least 8 competent servicemen, within 50 miles of the project site, for a period of not less than 10 years.

5. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last 4 years.

6. The system manufacturer/installer shall provide an experienced project manager for this work from beginning of control installation until final completion. The project manager is responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS manufacturer wishes to change the project manager, the construction manager and/or owner's representative must be notified immediately and both the new project manager and the previous project manager shall spend three (3) consecutive business days together on-site performing a project management switchover. Exceptions may be allowed for small projects as determined by the construction manager and/or owner's representative.

L. Comply with all current governing codes, ordinances and regulations including UL, NFPA, the local Building Code, NEC, etc.

M. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to primary control panels, secondary control panels, personal operator workstations and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

1.8 DELIVERY, STORAGE AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. System Software: Update to latest version of software at project completion.

1.9 COORDINATION

A. Coordinate location of temperature sensors, carbon dioxide sensors and other exposed control sensors with plans and room details before installation.

B. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

C. Coordinate BMS equipment with all relevant divisions including, but not limited to, Fire Alarm to achieve compatibility with equipment that interfaces with that system.

D. Coordinate BMS equipment to achieve compatibility with motor starters and annunciation devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. Automated Control Logic.

2. Honeywell, Inc (AME, Inc).

3. TAC Controls (TBS Controls, LLC).

2.2 CONTROL PANELS

A. Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide laminated as-built wiring diagrams, flow diagrams, etc. related to the system being controlled inside the associated cabinet. Each control panel shall be clearly and permanently labeled with the controller designation and indication of the mechanical equipment served.

B. Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. All panels shall have common keying. Provide appropriate NEMA rating for application with NEMA 4 rating at a minimum.

2.3 BMS SYSTEM ARCHITECTURE

A. There shall be one (1) primary control panel provided for control of the air handling unit dampers and connection of all air handling unit points. All VAV box controllers shall be networked to the air handling unit primary control panel. Upon acceptance of the alternate, the primary control panel shall be connected to the existing BMS network within the West portion of the building.

B. The BMS system shall use an architecture based on a modular network, utilizing industry standard operating systems, networks and protocols.

C. The system shall allow the distribution of system functions such as monitoring and control and graphical user interface etc. across the network to achieve maximum flexibility and performance.

2.4 BMS NETWORK

A. The design of the BMS shall network the primary control panel and all secondary control panels.

B. The BMS design shall allow the co-existence of current and future control panels on the same primary.

C. Network

1. The network shall connect and support stand-alone secondary control panels and shall communicate bi-directionally with the primary control panel for transmission of global data.

2.5 PRIMARY CONTROL PANEL HARDWARE

A. Provide one (1) primary control panel for the air handling units. The primary control panel shall be provided with and LED/LCD display and pushbutton interface on the face of the panel. The display and pushbuttons shall allow the operator to view and adjust all points. The primary control panel shall be wall-mounted in the mechanical equipment room.

B. Spare Capacity

1. All primary control panels shall be installed with 10% spare points (of each type) and 10% spare memory capacity for future connections. The type of spare point capacity shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two (2) spares of each implemented I/O type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2. Provide all processors, power supplies and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

   a. Expansion modules.

   b. Sensor/actuator.

   c. Field wiring/tubing.

C. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

D. Each primary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated metal enclosure.

2. An integral real-time clock.

3. A 32bit, stand-alone, multi-tasking, multi-user, real-time 48M Hz digital control microprocessor module.

4. Primary Network communication module, if needed for primary network communications.

5. Secondary Network communication module, if needed for secondary network communications.

6. Memory to accommodate all primary control panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications. Controller shall have a minimum of 32 MB RAM, 1 MB of flash, and 16K EPROM or EEPROM. Controller shall be provided with battery backup capable of supporting all RAM, clock functions, DDC database and operating programs within the controller for a minimum of 72 hours in the event of power failure or power interruption (if information is not stored in non-volatile memory).

7. Data collection/ Data Trend module sized for 10,000 data samples.

8. Power supplies as required for all associated modules, sensors, actuators, etc.

9. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

10. A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

11. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

12. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent to the primary enclosure.

E. Each primary control panel shall continuously perform self-diagnostics on all hardware modules and network communications. The primary control panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication with any system.

F. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM.

G. Each primary control panel shall support firmware upgrades without the need to replace hardware.

H. Immunity to power and noise.

1. Controller shall be able to operate at 90% – 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2. Operation shall be protected against electrical noise of 5 – 120 Hz and from keyed radios up to 5W at 1m (3').

3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.

b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8kV air discharge, 4kV contact.

c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1kV power.

d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

4. Isolation shall be provided at all Primary Controller's AC input terminals to suppress induced voltage transients consistent with:

a. IEEE Standard 587 1980.

b. UL 864 Supply Line Transients.

c. Voltage Sags, Surge and Dropout per EN 61000-4-11 (EN 1000-4-11).

## 2.6 PRIMARY CONTROL PANEL SOFTWARE

A. Furnish the following applications software to form complete operating system for building and energy management as described in this specification.

B. Provide all necessary software for a complete operating system as required. All software shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

C. All points, panels and programs shall be identified by a 30 character name and a 16 character point descriptor.

D. All digital points shall have a user-defined, 2-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).

E. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications and system functions as assigned by the system manager.

3. Primary Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface. Passwords and priorities for every point shall be fully programmable and adjustable.

4. User Log On / Log Off attempts shall be recorded.

F. Each primary control panel shall, at a minimum, be provided with software for:

1. 2-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.

2. Limiting the number of times each piece of equipment may be cycled within any 1-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

4. Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/ cooling interlock, supply temperature reset, priority load shedding and power failure restart.

5. Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

a. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

b. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

c. Any process shall be able to issue commands to points in any and all other controllers in the system.

d. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

e. The custom control programming feature shall be documented via English language descriptors.

f. Each controller shall support text comment lines in the operating program to allow for quick troubleshooting, documentation and historical summaries of program development.

g. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

6. Generate and receive automatic and manual operator messages and advisories.

7. Comment lines for all programs.

8. Distributed independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of 6 priority levels shall be provided for each point.

9. Automatically accumulate and store run-time hours for all digital points.

10. Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

G. Trend data shall be stored at the primary control panels and automatically uploaded to the PC workstation. Uploads shall occur based on user-defined intervals, manual commands, or automatically when the trend buffer is 80% full. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS.

H. Primary control panels shall be able to access any data from, or send control commands and alarm reports directly to, any other primary control panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary control panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

I. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report

alarms be affected by either operator activity, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of 6 priority levels shall be provided for each point. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages shall be routed to user-defined list of operator workstations or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages and display graphics.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

    a. Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

5. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

J. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.

2. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

3. For points assigned to one (1) common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.

4. The operator shall be able to define the following information:

    a. Time, day.

    b. Commands such as on, off, auto and so forth.

    c. Time delays between successive commands.

    d. There shall be provisions for manual overriding of each schedule by an appropriate operator.

5. It shall be possible to schedule calendar-based events up to 1 year in advance based on the following:

a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

K. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

L. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

M. Enthalpy switchover (economizer). The Primary Controller Software shall control the position of the air handler relief, return and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the software will modulate the dampers to provide 100% outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

N. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point and PID gains shall be user-selectable.

O. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

P. Staggered Start:

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.

2. Upon the resumption of power, each Primary Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

Q. Totalization:

1. Run-Time Totalization. Primary Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. Consumption totalization. Primary Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. Event totalization. Primary Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

R. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two (2) methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

b. Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically when the trend buffers are 80% full. All trend data shall be available for use in any third party personal computer applications located on the MLN.

c. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for a minimum of 36 operator-selected PID control loops. Provide capability to view or print trend and tuning reports.

1) The controller shall perform a step response test with a minimum 1-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.

2) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation, or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

S. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

T. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for all analog and digital pulse input type points.

U. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all

points. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

2.7 SECONDARY CONTROL PANEL HARDWARE

A. Each secondary control panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

B. Each Primary Controller shall be able to communicate with secondary controllers over the Secondary Network to control terminal equipment only.

C. Each secondary controller shall include all point inputs and outputs necessary to perform the specified control sequences. The secondary controller shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs may be utilized either for 2-state, modulating, floating or proportional control, allowing for additional system flexibility.

D. Provide a secondary control panel for each of the following types of equipment:

1. Variable Air Volume (VAV) Boxes.

2. Other terminal equipment.

E. Each secondary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated enclosure.

2. A stand-alone real-time digital control microprocessor module.

3. Secondary network communications ability.

4. Power supplies as required for all associated modules, sensors, actuators, etc.

5. Input/output points as required.

6. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

7. A portable operator terminal connection port.

8. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

9. Each controller measuring air volume shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

10. Each controller measuring air volume shall include a differential pressure transducer.

11. Integral damper actuator for VAV box applications.

F. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

G. Control Algorithms. The controller shall receive its real-time data from the Primary Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

H. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

I. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

J. Each secondary control panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The secondary control panel shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication to the system.

K. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24 VAC floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable.

L. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable. Controller shall have a minimum of 16K EPROM or EEPROM.

M. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 – 28 VAC (-25% – 17%),

allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The BMS contractor shall provide a dedicated power source and separate isolation transformer for each controller to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly. Power supply must be rated at a minimum of 125% of power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

1. The existing line voltage power trunk and installing separate isolation transformers for each controller.

2. Dedicated line voltage power source and isolation transformers at a central location and installing 24 VAC power trunk to supply multiple controllers in the area.

N. Environment. The controllers shall function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

O. Immunity to noise. Operation shall be protected against electrical noise of 5 – 120Hz and from keyed radios up to 5W at 1m (3').

2.8 SECONDARY CONTROL PANEL SOFTWARE

A. Provide all necessary software for a complete operating system as required. All software shall reside in each secondary control panel. Secondary control panels shall not be dependent upon any higher level computer or another controller for operation.

B. Secondary control panel software configured for VAV control algorithms shall include provisions for manual and automatic calibration of attached differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

C. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator's terminal.

D. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat, Fan-powered VAV and Fan-powered VAV with hot water or electric reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to

allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.9 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion or duct mounting as required.

B. Instruments and control devices shall be provided for all required points detailed herein. Instruments shall have accuracies as stated herein. Instrument characteristics such as hysteresis, relaxation time, span, and maximum and minimum limits, shall be accounted for in applications of instruments and controls. Not all devices specified may be required for this project.

C. Field wiring for each digital device shall be as per the manufacturer's standard. The details of the wiring shall be included in the submittal.

D. Sensors for duct locations shall not be affected by vibrations encountered in normal duct systems.

E. Temperature Sensors

1. Temperature sensors used in duct or space sensing applications shall be thermistors. Temperature sensors shall have the following characteristics.

   a. Accuracy: $\pm$0.5ºF.

   b. Wire: Twisted, shielded-pair cable.

2. Insertion Elements in Ducts: Single point; use where not affected by temperature stratification or where ducts are smaller than 9sq ft. (1sq m). The length of the sensor shall be a minimum of one-third of the width of the duct with a maximum length of eighteen (18) inches. Provide duct mounted metal housing with conduit entrance.

3. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9sq ft (1sq m); length as required. The length of the sensor shall be twelve (12) feet minimum or one (1) linear foot per every one (1) sq ft of cut cross section, whichever is greater. Provide duct mounted metal housing with conduit entrance.

4. Space sensors:

   a. Set-Point Adjustment: Concealed.

   b. Set-Point Indication: Concealed.

   c. Thermometer: None.

   d. Color: White.

   e. Orientation: Vertical.

   f. Occupancy override with an adjustable time period from 1/2 to 3 hours.

g. Provide a communication port for connection of a laptop or other portable interface device.

F. Carbon Dioxide Sensors: Silicon-based NDIR sensor.

1. Accuracy: 2% of reading ±30 ppm.

2. Linearity: ±1%.

3. Range: 0-2000 ppm.

4. Space sensors shall be Vaisala GMW21 or pre-approved equal.

5. Duct sensors shall be Vaisala GMD20 or pre-approved equal.

6. Outside air sensors shall be provided with an analog temperature reading and shall be Vaisala GMA20T or pre-approved equal.

G. Equipment operation sensors as follows:

1. Status Inputs for Electric Motors: Current sensor with current transformers, adjustable and set to 175% of rated motor current.

H. Current Sensor

1. Provide and install current sensors for all motor status points. Current sensor shall be split core, 2-wire, loop powered and sized for expected amperage with adjustable trip point. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint and loop power failure. The current sensor output shall be N.O., solid state and rated for 0.1A at 30 VAC/DC. Current sensor shall be manufactured by Hawkeye or pre-approved equal.

2.10 THERMOSTATS

A. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, or automatic-reset switch that trips if temperature sensed across any 12” of bulb length is equal to or below set point. Setpoint shall be adjustable.

1. Bulb Length: Minimum 20’.

2. Quantity: one (1) thermostat for each cooling coil or for every 20 sq ft of coil surface, whichever is greater.

2.11 FLOW MEASURING STATIONS/DEVICES

A. Airflow/Temperature Measurement Device

1. Provide airflow/temperature measurement devices (ATMD) where specified and/or indicated on the plans.

2. Each ATMD shall consist of one (1) or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a. Each sensor assembly shall contain 2 individually wired, hermetically sealed bead-in-glass thermistors.

b. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

c. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.

d. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.

e. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.

f. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.

g. Devices using less than two (2) thermistors in each sensor assembly are not acceptable.

h. Devices using platinum wire RTDs are not acceptable.

i. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.

3. All Sensor Probes

a. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.

b. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).

c. Airflow accuracy shall be $\pm$2% of reading over the entire operating airflow range.

1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

d. Temperature accuracy shall be $\pm$0.15°F over the entire operating temperature range of -20°F to 160°F.

e. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).

f. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g. Each sensor assembly shall not require matching to the transmitter in the field.

h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

4. Duct and Plenum Probes

a. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

b. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using 1 of the following options:

1) Insertion mounted through the side or top of the duct.

2) Internally mounted inside the duct or plenum.

3) Standoff mounted inside the plenum.

c. The number of sensor housings provided for each location shall be as follows:

d.

| Duct or Plenum Area (sq. ft) | Total # Sensors/Location |
|---|---|
| <2 | 4 |
| >2 and <4 | 6 |
| >4 and <8 | 8 |
| >8 and <16 | 12 |
| >16 | 16 |

e. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Transmitters

a. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

b. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

c. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

1) The transmitter shall use a switching power supply fused and protected from transients and power surges.

2) The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.

3) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

d. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be installed at a location that is protected from weather and water.

e. The transmitter shall be capable of communicating with other devices using 1 of the following interface options:

1) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10 VDC/4-20 mA (4-wire).

6. The ATMD shall be UL listed as an entire assembly.

7. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

a. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

8. Provide Ebtron Model GTx116-P or pre-approved equal.

2.12 AUTOMATIC CONTROL VALVES

A. All automatic control valves shall meet the following requirements:

1. Fully proportioning.

2. Capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements.

3. Body pressure rating and connection type construction shall conform to piping and fittings in which the valve is to be installed and to the valve schedules.

4. Control valves 2" and smaller shall have screwed connections.

5. Control valves larger than 2-1/2" shall have flanged connections.

B. Water Control Valves: Chilled water, hot water, glycol, and condenser water

1. Modulating control valves shall have the following characteristics:

a. Valve shall be one size below pipe size.

b. Valve shall have replaceable seat, plug, or disc.

c. Equal percentage flow characteristic (characterized ball or globe type valves).

d. Valve body shall be bronze, cast iron, forged brass or red brass.

e. Ball valve shall have stainless steel stem, stainless steel ball, and PTFE seats.

f. Globe valve shall have stainless steel steam and single stainless steel seat.

g. Two-Way Valve

1) Calculate Cv based upon maximum design flow and a pressure drop equal to the pressure drop through the coil with a maximum of 5 psi (35 kPa).

2) Valve actuator and trim shall provide close-off (differential) pressure ratings greater than or equal to 150% of the total system (pump) head.

C. Control valves shall be Belimo, Honeywell, Johnson Controls, Siemens or pre-approved equal.

D. All valve actuators shall meet the following requirements:

1. All valve actuation shall be electric. Pneumatic actuation is not acceptable.

2. Valve actuators shall:

a. Be quiet in operation.

b. Provide smooth modulation at design flow and pressure conditions.

c. Be capable of operating in sequence with other valves and/or damper actuators when required by the sequence of operation.

d. Be sized to close against a differential pressure equal to the design pump head plus 15%. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.

e. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe positions are as follows:

1) Reheat Coil Valves Fail Closed

2) Radiation Valves Fail Open

3. Incremental Electronic Actuator for Terminal Equipment Valve Actuation

a. Incremental actuators shall be allowed for terminal equipment only.

b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.

c. Actuators shall be equipped with a permanent manual adjustment.

d. Minimum Torque: 35” lb.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3-wire floating, 0 – 10 VDC or 4 – 20 mA.

g. Frequency: 50 – 60 Hz.

h. Power Consumption: 1.5VA maximum.

i. Spring Return Time: 20 sec maximum.

j. Spring return position should be field adjustable with a switch.

k. Nominal Force: 90lb Minimum.

l. Stroke: 7/32" (5.5mm) maximum.

m. For use when the maximum media temperature is 230°F.

2.13 DAMPER ACTUATION

A. All damper actuation shall be electric. Pneumatic actuation is not acceptable.

B. All damper actuators shall meet the following requirements:

1. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

2. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

3. Actuators shall be sized with a torque greater than 150% of the design damper torque.

4. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.

5. Incremental Electronic Actuator for Terminal Equipment Damper Actuation

a. Incremental actuators shall be allowed for terminal equipment only.

b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.

c. Actuators shall be equipped with a permanent manual adjustment.

d. Minimum Torque: 35” lb.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 mA.

g. Frequency: 50 – 60 Hz.

h. Power Consumption: 1.5VA maximum.

i. Nominal Force: 90lb Minimum.

j. Stroke: 7/32" (5.5mm) maximum.

k. For use when the maximum media temperature is 230°F.

C. Damper actuators shall be Belimo or pre-approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install software in control units. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. All control components including automatic control valves, dampers, instruments, sensors, etc shall be tagged for identification. Acceptable methods of tagging are: laminated plastic, stamped metal and engraved plastic.

D. Install equipment level and plumb.

E. Install all control devices as per the manufacturer's installation guidelines.

F. Ensure that averaging temperature sensors and freezestats are installed uniformly across each coil or duct and provide sufficient coverage.

G. Verify location of temperature sensors, carbon dioxide sensors and other exposed control sensors with plans and room details before installation. Locate all 60" above the floor or as otherwise required by ADA.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

H. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

I. Install electronic cables according to Division 26.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings and related wiring accessories.

B. All exposed wiring and wiring in mechanical equipment rooms shall be installed in conduit. New conduit shall be installed for all new wiring.

C. Plenum rated cable shall be acceptable in hung ceilings, walls and raised floors.

D. All wiring located outside shall be installed in rigid conduit, seal tite or EMT with compression fittings.

E. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

F. Install cable in raceway.

G. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

H. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

I. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

J. Wires and cables shall be as follows:

1. Single Conductor (120 VAC): Type THWN 12AWG stranded copper with 600V insulation.

K. Communications Network Cabling

1. Cable shall be of type recommend by the DDC System Manufacturer and 20AWG at a minimum.

2. Cable shall be shielded.

L. Room Sensor Cabling

1. Cable shall consist of copper conductors not less than No. 24 AWG.

M. Cables for 120 VAC wiring and low level signal wiring (i.e., 4 – 20 mA analog) shall always be run in separate raceways.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units and retest.

2. Test and adjust controls and safeties.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing and control sequences.

3. Adjust, calibrate and fine tune circuits and equipment to achieve sequence of operation specified.

D. Verification

1. Verify that instruments are installed before calibration, testing and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth and other applicable considerations.

4. Check temperature instruments and material and length of sensing elements.

5. Check control valves. Verify that they are in correct direction.

6. Check DDC system as follows:

   a. Verify that DDC controller power supply is from emergency power supply, if applicable.

   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

   c. Verify that spare I/O capacity has been provided.

   d. Verify that DDC controllers are protected from power supply surges.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Closeout Procedures" and "Demonstration and Training."

3.5 TRAINING

A. The BMS contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

B. Provide sixteen (16) hrs of training for Owner's operating and maintenance personnel. All training shall be on-site training. Training shall include:

   1. Explanation of drawings, operators and maintenance manuals.

   2. Walk-through of the job to locate all control components.

   3. Operator interface.

   4. DDC Controller operation/function.

   5. Operator control functions and field panel programming.

   6. Explanation of adjustment, calibration and replacement procedures.

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.6 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within 1 year of date of Substantial Completion, provide up to three (3) Project-site visits, when requested by Owner, to adjust and calibrate components and to

assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.7 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media and include the following for the BMS provided:

a. Table of contents.

b. As-built system record drawings. Record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

c. Manufacturers product data sheets or catalog pages for all products including software.

d. System Operator’s manuals.

e. Archive copy of all site-specific databases and sequences.

f. BMS network diagrams.

g. Interfaces to all third-party products and work by other trades.

B. The Operation and Maintenance Manual CD shall be self-contained and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom and search all documents.

3.8 WARRANTY

A. The BMS shall include a one (1) year parts and labor warranty to begin upon system acceptance that covers the entire system to correct any operational issues at no additional cost to the Owner. The warranty shall cover adjustment and calibration of components and assistance to building personnel in making program changes and in adjusting sensors and controls to suit actual conditions. System acceptance shall be determined by the Owner.

B. During the warranty period, the Contractor shall guarantee the following in a form satisfactory to the Owner:

1. All work installed will be free from any and all defects in workmanship and or materials.

2. All devices will operate as per the capacities and performance characteristics specified.

3. The systems shall operate without malfunction.

C. Maintain an adequate supply of materials within 100 miles of the Project site

D. Provide specific warranty details as part of the proposal and submittal.

END OF SECTION 230900

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SECTION 230993 - SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems and equipment.

1.3 DEFINITIONS

A. AHU: Air Handling Unit.

B. AI: Analog Input.

C. AO: Analog output.

D. BMS: Building Management System.

E. CFM: Cubic Feet per Minute.

F. DDC: Direct-digital controls.

G. DI: Digital Input.

H. DO: Digital Output.

I. FAS: Fire Alarm System.

J. HVAC: Heating, Ventilating and Air Conditioning.

K. VAV: Variable air volume.

L. VFD: Variable Frequency Drive.

1.4 GENERAL

A. A failure alarm, as included in the point list, shall indicate the type of equipment that has failed (fan, etc.) including the specific designation of the piece of equipment (e.g., supply fan SF-1). It is not acceptable to generate a general failure alarm.

B. All setpoints including setpoints internal to control algorithms shall be adjustable from all BMS operator interfaces. All commands shall be overrideable from all BMS operator interfaces. All control points shall be adjustable or overrideable from the same graphic page that displays the points.

C. All points required by the sequence of operation including, but not limited to, the points listed in the sequences of operation below, as well as all of the points' associated values, shall be

connected to the BMS and available to the BMS operators on all operator workstations and all operator interface devices.

D. The installed BMS shall have dedicated, LAN based communication buses independent of the building IT network for both primary and secondary buses.

E. All valves, dampers, controllers, control devices, etc. exposed to outside air conditions shall be specifically designed for outside air conditions including, but not limited to, NEMA 4 enclosures, weatherproof enclosures and all other weather precautions recommended by the manufacturer.

F. All alarms associated with equipment that is disabled shall be inhibited.

G. All initial field settings applied shall be saved as the default values. These values shall be downloaded to the controller such that they are the default value if the controller loses power. A printed copy shall also be provided to the owner as part of the O & M manuals.

1.5 EXISTING AIR HANDLING UNITS (TYPICAL OF THREE (3))

A. General

1. The BMS contractor shall disconnect the dampers from the existing controls. The existing actuators shall remain but shall be controlled by the new DDC control panel according to the sequence of operation contained herein. There are two (2) actuators for the outside air dampers and two (2) actuators for the return air dampers. Upon connection of the damper actuators to the new DDC system, ensure that the two (2) outside air and two (2) return air dampers actuators open/close simultaneously

2. The BMS contractor shall furnish, install and wire a new outside air temperature sensor.

3. The BMS contractor shall furnish, install and wire the following for each unit:

a. A new mixed air temperature sensor.

b. A new return air temperature sensor.

c. A new outside air flow monitoring station.

d. New freezestats (quantity as required by section 230900). The new freezestats shall be wired to the DDC control panel and to the existing controls. The existing freezestats shall be disconnected from the existing controls and removed. The new freezestats shall be connected in parallel and wired to the existing controls in the same manner the existing freezestats were connected.

B. Safeties

1. If a freezestat is activated, the outside air dampers shall close, the return air dampers shall open and the unit shall be shutdown. The alarm must be reset via the DDC control panel prior to the unit restarting.

2. If the unit is commanded on and there is a loss of supply fan status, the outside air dampers shall close and the return air dampers shall open.

C. Warm-Up

1. A warm-up program shall be invoked if the return air temperature is below 60°F (adj.) upon unit start up. During the warm-up mode, the air handling unit shall operate on 100% return air. After warm-up (return air above 65ºF (adj.)), the unit shall be controlled as described in occupied mode.

D. Occupied mode

1. The air handling unit shall be started based upon a time of day schedule or manual command. The existing time clocks shall be disconnected and the existing controls shall be started stopped by the new DDC control panel.

2. Upon a command to start, the outside air dampers shall modulate to minimum position and the return air damper shall modulate to maximum position. The exhaust air dampers are barometric dampers and shall operate independent of the DDC system.

3. The minimum position of the outside air damper shall be determined by the reading of the outside air flow measuring station. The outside air damper shall not close beyond the position required to supply the minimum outside air CFM setpoint.

4. The outside air and return air dampers shall modulate as necessary to maintain the mixed air temperature setpoint. The BMS shall compare the outside air temperature to the return air temperature and determine whether the outside air dampers shall modulate open or closed to maintain the mixed air temperature setpoint. If the outside air temperature is below the return air temperature, the outside air damper shall modulate open upon a rise in mixed air temperature above setpoint and closed upon a fall in mixed air temperature below setpoint. If the outside air temperature is above the return air temperature, the outside air damper shall modulate closed upon a rise in mixed air temperature above setpoint and open upon a fall in mixed air temperature below setpoint.

5. The return air damper shall modulate closed proportionately as the outside air damper modulates open and shall modulate open proportionately as the outside air damper modulates closed.

6. If a VAV box is fully open and the associated space carbon dioxide level rises above 800 ppm (adj.), the outside air dampers shall be overridden open as necessary to maintain the space carbon dioxide level at setpoint. The return air damper shall modulate closed proportionately as the outside air dampers modulate open and shall modulate open proportionately as the outside air dampers modulate closed. If all space carbon dioxide levels are at or below setpoint, the dampers shall remain under temperature control.

E. Unoccupied mode

1. The return air damper shall open and the outside air dampers shall close. The unit shall be disabled.

F. Provide the following points hardwired to the primary control panel for each air handling unit:

1. AI: mixed air temperature.

2. AI: return air temperature

3. AI: outside air CFM.

4. AI: outside air temperature (only one (1) sensor is required, not one (1) for each unit).

5. AO: outside air damper control (0-100%).

6. AO: return air damper control (0-100%).

7. DI: freezestat status.

8. DI: supply fan status.

9. DO: start/stop (to existing controls based on time of day schedule).

G. Provide the following points on the primary control panel display in addition to the hardwired points indicated above:

1. AHU command (on/off).

2. AHU mode (occupied/unoccupied/warm-up).

3. High and low mixed air temperature alarms.

4. High space carbon dioxide level (indicated if any space rises above 1000 ppm).

5. Minimum outside air CFM setpoint.

6. Mixed air temperature setpoint.

7. Space carbon dioxide level setpoint.

8. Supply fan failure.

9. Time of day schedule (fully adjustable).

1.6 VARIABLE AIR VOLUME (VAV) BOXES WITH HOT WATER REHEAT SERVING COURTROOMS

A. General

1. The BMS contractor shall furnish and install a space carbon dioxide sensor in each of the three (3) court rooms. The courtrooms are each served by two (2) VAV boxes. The VAV boxes shall each be provided with a space temperature sensor and shall control to maintain temperature independently. If the space carbon dioxide level rises too high, both VAV boxes serving the space will be overridden.

B. Occupied mode

1. Upon a fall in space temperature below setpoint, the box damper shall modulate closed to the minimum CFM setpoint. Upon a further fall in space temperature, the box damper shall modulate to the heating CFM setpoint and the hot water reheat valve shall modulate as necessary to maintain the space temperature setpoint.

2. Upon a rise in space temperature, the hot water reheat valve shall close. Upon a further rise in space temperature, the box damper shall modulate from the minimum to the

maximum CFM setting as necessary to maintain the CFM setpoint as reset by the space temperature.

3. Upon a rise in space carbon dioxide level above 750 ppm (adj.), the VAV box shall be overridden to the maximum CFM setting. The reheat coil shall modulate as necessary to maintain the space temperature setpoint. The VAV box shall remain overridden to maximum CFM until the space carbon dioxide level falls below setpoint for a period of 15 minutes (adj.). If the space carbon dioxide level is at or below setpoint, the VAV box shall remain under temperature control

C. Unoccupied mode

1. The VAV box damper shall close and the reheat valve shall remain closed.

D. The VAV box shall not open beyond the maximum CFM setting. Provide one (1) DDC controller and one (1) temperature sensor for each VAV box. The minimum and maximum CFM settings shall be those scheduled on the mechanical drawings.

E. Provide the following points hardwired to the VAV box controller:

1. AO: damper control (0-100%).

2. AO: reheat valve control (0-100%).

3. AI: space carbon dioxide.

4. AI: space temperature.

5. AI: supply air CFM.

F. Provide the following points on the primary control panel display in addition to the hardwired points indicated above:

1. Box enable/disable.

2. Carbon dioxide level setpoint.

3. Heating/cooling space temperature setpoints.

4. Occupied/unoccupied command.

5. Space/area served.

6. Supply air CFM setpoint.

1.7 VARIABLE AIR VOLUME (VAV) BOXES WITH HOT WATER REHEAT SERVING JURY ROOMS

A. General

1. The BMS contractor shall furnish and install a space carbon dioxide sensor in each of the three (3) jury rooms. Each jury room is served by a VAV box.

B. Occupied mode

1. Upon a fall in space temperature below setpoint, the box damper shall modulate closed to the minimum CFM setpoint. Upon a further fall in space temperature, the box damper shall modulate to the heating CFM setpoint and the hot water reheat valve shall modulate as necessary to maintain the space temperature setpoint.

2. Upon a rise in space temperature, the hot water reheat valve shall close. Upon a further rise in space temperature, the box damper shall modulate from the minimum to the maximum CFM setting as necessary to maintain the CFM setpoint as reset by the space temperature.

3. Upon a rise in space carbon dioxide level above 750 ppm (adj.), the VAV box shall be overridden to the maximum CFM setting. The reheat coil shall modulate as necessary to maintain the space temperature setpoint. The VAV box shall remain overridden to maximum CFM until the space carbon dioxide level falls below setpoint for a period of 15 minutes (adj.). If the space carbon dioxide level is at or below setpoint, the VAV box shall remain under temperature control

C. Unoccupied mode

1. The VAV box damper shall close and the reheat valve shall remain closed.

D. The VAV box shall not open beyond the maximum CFM setting. Provide one (1) DDC controller and one (1) temperature sensor for each VAV box. The minimum and maximum CFM settings shall be those scheduled on the mechanical drawings.

E. Provide the following points hardwired to the VAV box controller:

1. AO: damper control (0-100%).

2. AO: reheat valve control (0-100%).

3. AI: space carbon dioxide.

4. AI: space temperature.

5. AI: supply air CFM.

F. Provide the following points on the primary control panel display in addition to the hardwired points indicated above:

1. Box enable/disable.

2. Carbon dioxide level setpoint.

3. Heating/cooling space temperature setpoints.

4. Occupied/unoccupied command.

5. Space/area served.

6. Supply air CFM setpoint.

1.8 VARIABLE AIR VOLUME (VAV) BOXES WITH HOT WATER REHEAT

A. Occupied mode

1. Upon a fall in space temperature below setpoint, the box damper shall modulate closed to the minimum CFM setpoint. Upon a further fall in space temperature, the box damper shall modulate to the heating CFM setpoint and the hot water reheat valve shall modulate as necessary to maintain the space temperature setpoint.

2. Upon a rise in space temperature, the hot water reheat valve shall close. Upon a further rise in space temperature, the box damper shall modulate from the minimum to the maximum CFM setting as necessary to maintain the CFM setpoint as reset by the space temperature.

B. Unoccupied mode

1. The VAV box damper shall close and the reheat valve shall remain closed.

C. The VAV box shall not open beyond the maximum CFM setting. Provide one (1) DDC controller and one (1) temperature sensor for each VAV box. The minimum and maximum CFM settings shall be those scheduled on the mechanical drawings.

D. Provide the following points hardwired to the VAV box controller:

1. AO: damper control (0-100%).

2. AO: reheat valve control (0-100%).

3. AI: space temperature.

4. AI: supply air CFM.

E. Provide the following points on the primary control panel display in addition to the hardwired points indicated above:

1. Box enable/disable.

2. Heating/cooling space temperature setpoints.

3. Occupied/unoccupied command.

4. Space/area served.

5. Supply air CFM setpoint.

1.9 VARIABLE AIR VOLUME (VAV) BOXES WITH HOT WATER REHEAT AND ASSOCIATED FIN TUBE RADIATION

A. Occupied mode

1. Upon a fall in space temperature below setpoint, the box damper shall modulate closed to the minimum CFM setpoint. Upon a further fall in space temperature, the fin tube radiation valve shall modulate as necessary to maintain the space temperature setpoint. If the fin tube radiation valve is fully open and there is a fall in space temperature, the box

damper shall modulate to the heating CFM setpoint and the hot water reheat valve shall modulate as necessary to maintain the space temperature setpoint. The fin tube radiation valve shall remain fully open when the VAV box reheat valve is open.

2. Upon a rise in space temperature, the hot water reheat valve shall close. Upon a further rise is space temperature, the fin tube radiation valve shall close. Upon a further rise in space temperature, the box damper shall modulate from the minimum to the maximum CFM setting as necessary to maintain the CFM setpoint as reset by the space temperature.

B. Unoccupied mode

1. The VAV box damper shall close and the reheat valve shall remain closed. The fin tube radiation valve shall modulate as necessary to maintain the unoccupied space temperature setpoint.

C. The VAV box shall not open beyond the maximum CFM setting. Provide one (1) DDC controller and one (1) temperature sensor for each VAV box and the associated fin tube radiation. The minimum and maximum CFM settings shall be those scheduled on the mechanical drawings.

D. Provide the following points hardwired to the VAV box controller:

1. AO: damper control (0-100%).

2. AO: fin tube radiation valve control (0-100%).

3. AO: reheat valve control (0-100%).

4. AI: space temperature.

5. AI: supply air CFM.

E. Provide the following points on the primary control panel display in addition to the hardwired points indicated above:

1. Box enable/disable.

2. Occupied/unoccupied, heating/cooling space temperature setpoints.

3. Occupied/unoccupied command.

4. Space/area served.

5. Supply air CFM setpoint.

1.10 ALTERNATE - TIE-IN TO EXISTING BMS

A. Provide an alternate cost to tie-in to the existing BMS located in the West portion of the building. Work shall include:

1. Provide a SEAMLESS tie-in to the existing BMS. The tie-in shall include Direct Digital Control (DDC), historical data collection, archiving and alarm, energy and information management for all control points specified herein.

2. Tie-in to existing site BMS of all DDC equipment and points as specified in this section and as required in all other referenced sections and as required to complete the sequences of operation outlined herein. Tie-in shall be made via an extension of the existing BMS.

3. Provide new color graphics for all new systems specified in this contract.

4. Revisions to all existing BMS workstations as required to incorporate the additional control components provided under this section. Revisions shall include, but are not limited to, revised graphics, update of additional firmware and/or software as required to accommodate new points.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION 230993

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.

B. Related Sections include the following:

1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

C. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the minimum working pressure and temperature of the systems listed in the PIPING APPLICATIONS section in Part 3 and as follows:

1. Medium temperature Hot-Water Heating Piping: (160 PSIG)<**Insert psig (kPa)**> at [220 deg F to 350 deg F supply temperature)] <**Insert temperature**>.
2. Hot-Water Heating Piping: 120 **psig (kPa)** at [**200 deg F (93 deg C)**] <**Insert temperature**>.

1.5 SUBMITTALS

A. Product Data: For each type of the following:

1. Submit a schedule indicating the following:

    a. System.,Service,Operating temperature,Operating pressure, Pipe material, Fittings, Methods of joining, Gaskets, Specialties, Test pressure, Flange gaskets, , Fittings., Unions, Dielectric unions, Suction diffusers, Ring spacers and test blanks.

2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
3. Strainers
4. Air control devices.
5. Chemical treatment.
6. Hydronic specialties.

B. Shop Drawings: Detail, at 3/8 inch scale piping layout with fittings, valves and equipment, use single line for pipe sizes 3 inches and smaller, and double line for pipe sizes 4 inches and greater. fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops

1. Minimum 3/8 inch scale double line layout and sections where required or coordination drawings.

C. Welding certificates.

D. Qualification Data: For Installer.

E. Field quality-control test reports, Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

F. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

G. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications:

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

E. Steel Pipe Welding:

1. Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”
2. Welders shall be qualified for all required pipe sizes, material, wall thickness, and position in accordance with the American Society of Mechanical Engineering (ASME) Section IX, boiler and pressure Vessel Code
3. Copies of the certified welder qualification reports shall be maintained by the responsible welding agency and the company performing the welding, and shall be submitted to the owner and/or Inspector upon request.
4. All defective welds shall be chipped out and repaired at no cost to the Owner, based on procedure to be specified at the time.
5. The contractor shall bear the cost of reinspection of the repaired welds and the inspection of two (2) additional welds, as selected by the owner, for each failed weld.
6. Field Procedures:

    a. Clean pipe free from rust, scale and oxide.
    b. Bevel pipe on each end per acceptable procedures.
    c. Contractor is responsible for preparation of pipe in accordance with ASME B 31.1, Chapter V and for visual inspection during the welding operation and for all required welding examinations with certified welding inspector(s), in accordance with ANSI/AWS B.1.10-86 or latest issue section 3.1, 3.1.1, 3.1.2, and 3.1.3.

F. Copper Tube Brazing

1. Qualify process and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, “Welding and Brazing Qualifications”
2. Brazers shall be qualified for all required tube sizes, material, wall thickness, and position in accordance with the American Society of Mechanical Engineering (ASME), Section IX, boiler and Pressure Vessel Code.
3. Brazing qualification testing shall be performed an agency/laboratory certified by ASME.
4. Copies of the certified brazer qualification reports shall be maintained by the responsible brazing agency and the company performing the brazing, and shall be submitted to the owner and/or Inspector.
5. All defective brazements shall be chipped out and repaired at no cost to the Owner, based on procedure to be specified at the time.

6. The contractor shall bear the cost of re-inspection of the repaired brazements and the inspection of two (2) additional brazements, as selected by the owner, for each failed brazement.
7. Field Procedures:

    1) Clean tubing free from surface oxidation on the O.D.
    2) Ream all tubes and remove burrs created by the cutting operation, on each end per acceptable procedures.
    3) Contractor is responsible for preparation of tubes and for visual inspection during the brazing operation in accordance with all applicable ASME, ANSI and AWS standards.

1.7 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, structure and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping for fire and smoke wall and floor assemblies.

1.8 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. Wrought-Copper Fittings: ASME B16.22.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International, Inc.
    b. S. P. Fittings; a division of Star Pipe Products.

D. Wrought-Copper Unions: ASME B16.22.

## 2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

## 2.3 FIBERGLASS PIPE AND FITTINGS

A. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.

B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.

C. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch (3.2-mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

D. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
c. For high temperature water – Klinger C4500
d. For medium temperature water - Klinger C4500
e. For chilled water systems – Klinger suitable for glycol use.
f. For hot water – Klinger C4500
g. For joints of dissimilar metals, provide isolating gaskets, sleeves and washers between flanges, bolts and nuts. Gaskets shall be similar to Dupont Teflon

B. Flange Bolts, Studs, Nuts and Washers:

1. Bolts and studs shall be chrome-molybdenum bolt stud in accordance with ASTM A 193 grade B7 with full-length threads in accordance ANSI B 31.1. Length shall be sufficient to project beyond nuts three complete threads when joint is made.
2. Nuts shall be carbon-steel in accordance with ASTM A 194 Grade 2H. Nuts shall be hexagon heavy series type. Threads shall the same as for bolts.
3. Washers shall be flat, plain, stamped, in accordance with ANSI/ASME B18.22.1.

C. Ring Spacers and Test Blanks:

1. Provide between flanges where shown on drawing or where necessary to isolate equipment from the piping system, in accordance with B3.1.1, Chapter VI, section 137.2.4. Ring spacers to be replaced by test blanks during hydrostatic testing and/or during chemical cleaning for equipment isolation.
2. Size and rating to match companion flanges.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

1. Comply with Section II, Part C of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

## 2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Capitol Manufacturing company
    b. Hart Industries International, Inc.
    c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    d. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

D. Dielectric Flanges:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

3. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Calpico, Inc.
   b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

G. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

## 2.6 VALVES

A. Gate, Globe, Check, Ball, Butterfly, safety relief and balancing Valves,: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

## 2.7 AIR CONTROL DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amtrol, Inc.
2. Bell & Gossett Domestic Pump; a division of ITT Industries.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: **NPS 1/8** (**DN 6**).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/4 (DN 8).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

D. Expansion Tanks:

1. General:

a. Provide as shown on the drawings, a pressurization and air elimination system to accommodate the expanded water generated by the increase in temperature in the water system and to control the increase in pressure at all critical components in the system to the maximum allowable for those components.
b. The pressurization and air elimination system shall ensure that all air in the system shall be eliminated. The only air in the system shall be the permanent sealed in air cushion contained in the pressurization controller component of the system, a diaphragm type expansion tank, pre-charged to the minimum operating pressure at the location indicated on the drawing.
c. All free air originally contained in the system, and all entrained air bubbles carried by system water shall be eliminated at all points in the piping system where the capability of water to hold air in solution is lowest (the point of lowest solubility), and as indicated on the drawings. The air separating and elimination component shall separate entrained air from flowing system water by the creation of a vortex which will allow free air to rise in the center, the point of lowest velocity, to an air elimination valve.

2. Diaphragm or Bladder -Type Expansion Tanks:

a. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
b. [**Diaphragm or bladder**]: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
c. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
d. Orientation: Vertical.
e. Orientation: Horizontal.
f. Size and capacity as scheduled on the drawings.
g. Features:

1) Integral structural steel supports
2) Base for vertical tanks.
3) Cradle for horizontal tanks.
4) Gasketed handhole.
5) Gasketed manhole.

6) All tappings for gauge glass, instrumentation, drain, fill and connections to system: Refer to detail on the drawings.
7) Pre-charged with air to pressure scheduled on drawings.

E. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

F. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig (1207 kPa).
3. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

G. Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig (1035 kPa).
3. Maximum Operating Temperature: 250 deg F (121 deg C).

## 2.8 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Chilled Water, Condenser Water and Hot Water Systems of Steel Construction:

a. Working pressure: To 250 psig, non-shock.

1) Sizes 1/4 inch to 2 inch: ANSI 250 lb. Class.

a) Connections: Threaded.
b) Body: Cast iron, ASTM A126, Class B. With machined seat for screen retention. Galvanized as required to match connecting piping.
c) Cap: Bronze, gasketed.
d) Screen: 20 mesh. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area.
e) Blowoff outlet: With female NPT tapping.
f) Mueller model No. 11 MFCB.

2) Sizes 2-1/2 inch to 24 inch: Class 250.

a) Connections: Flanged.
b) Body: Cast iron, ASTM A126, Class B. With machined seat for screen retention. Galvanized as required to match connecting piping.
c) Cover flange: Cast iron, ASTM A126, Class B. With machined seat for screen retention. With female tapped NPT blowoff connection. With EPDM O-ring seal.
d) Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area.
f) Magnets: Provide magnets for strainers. All 8 inch and larger. At each pump suction. With continuous magnetic field around entire circumference of screen. With removable cast Alnico No. 5 channel magnets with acceptable baskets constructed of magnetic alloy. Secured with stainless steel retaining lugs and threaded rods.
g) Blowoff outlet: With female NPT tapping.
h) Mueller model No. 752.

b. Working pressure: To 285 psig at 100 deg F ANSI Class 150 and 740 psig at 100 deg F ANSI Class 300, non-shock:

1) Sizes 1/2 inch to 12 inch:

a) Connections: Flanged or butt welded to match piping system.
b) Body: Carbon steel, ASTM A216, Grade WCB. With machined seat for screen retention.
c) Cover: Carbon steel, ASTM 215, Grade WCB. With machined seat for screen retention. With female tapped NPT blowoff connection. With non-asbestos gasket.
d) Screen: Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
f) Magnets: Provide magnets for strainers. All 8 inch and larger. At each pump suction. With continuous magnetic field around entire circumference of screen. With removable cast Alnico No. 5 channel magnets with acceptable baskets constructed of magnetic alloy. Secured with stainless steel retaining lugs and threaded rods.
g) Blowoff outlet: With female NPT tapping.
h) Mueller model No. 761 for ANSI Class 150. Mueller model No. 762 for ANSI Class 300.

2) Sizes 14 inch to 24 inch:

a) Connections: Flanged or butt welded to match piping system.
b) Body: Carbon steel, ASTM A216, Grade WCB. With machined seat for screen retention.

c) Cover: Carbon steel, HRS plate. With machined seat for screen retention. With female tapped NPT blowoff connection. With non-asbestos gasket.
d) Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
f) Magnets: Provide magnets for strainers. All 8 inch and larger. At each pump suction. With continuous magnetic field around entire circumference of screen. With removable cast Alnico No. 5 channel magnets with acceptable baskets constructed of magnetic alloy. Secured with stainless steel retaining lugs and threaded rods.
g) Blowoff outlet: With female NPT tapping.
h) Mueller model No. 781 for ANSI Class 150.
i) Mueller model No. 782 for ANSI Class 300.

2. Chilled Water, Condenser Water and Hot Water and Glycol Systems of Copper Construction:

a. Working pressure: To 250 psig, non-chock.

1) Sizes 1/4 inch to 2 inch: Class 250

a) Connections: Threaded.
b) Body: Bronze, ASTM B62. With machined seat for screen retention.
c) Cap: Bronze, ASTM B62. With machined seat for screen retention.
d) Screen: 20 mesh. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 time inlet area.
e) Blowoff outlet: With female NPT tapping.
f) Mueller model No. 352M.

b. Working pressure to 225 psig Class 150; to 400 psig Class 300:

1) Sizes 2-1/2 inch to 12 inch:

a) Connections: Flanged.
b) Body: Bronze, ASTM B62 (85-5-5-5) or bronze ASTM B61. Aluminum bronze ASTM A148-90 for sizes 8 inch and larger. With machined seat for screen retention.
c) Cover: Material to match body. With machined seat for screen retention.
d) Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area.
f) Blowoff outlet: With female NPT tapping.
g) Mueller model No. 851 or 851M for Class 150.
h) Mueller model. No. 852 for Class 300.

3. Medium Temperature and High Temperature Water Systems:

a. Working pressure: To 150 psig at 565 deg F; ANSI Class 150 and 300 psig at 835 deg F; ANSI Class 300.

1) Sizes 1/2 inch to 12 inch:

a) Connections: Flanged or but welded to match piping system.
b) Body: Carbon steel, ASTM A216, Grade WCB. With machined seat for screen retention.
c) Cover: Carbon steel, ASTM 216, Grade WCB. With machined seat for screen retention. With female tapped NPT blowoff connection. With non-asbestos gasket.
d) Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
f) Magnets: Provide magnets for strainers. All 8 inch and larger. At each pump suction. With continuous magnetic field around entire circumference of screen. With removable cast Alnico No. 5 channel magnets with acceptable baskets constructed of magnetic alloy. Secured with stainless steel retaining lugs and threaded rods.
g) Blowoff outlet: With female NPT tapping.
h) Mueller model No. 761 for ANSI Class 150.
i) Mueller model No. 762 for ANSI Class 300.

2) Sizes 14 inch to 24 inch:

a) Connections: Flanged or butt welded to match piping system.
b) Body: Carbon steel, ASTM 216, Grade WCB. With machined seat for screen retention.
c) Cover: Carbon steel, HRS plate. With machined seat for screen retention. With female tapped NPT blowoff connection. With non-asbestos gasket.
d) Screen to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
e) Screen 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 4 times inlet area.
f) Magnets: Provide magnets for strainers. All 8 inch and larger. At each pump suction. With continuous magnetic field around entire circumference of screen. With removable cast Alnico No. 5 channel magnets with acceptable baskets constructed of magnetic alloy. Secured with stainless steel retaining lugs and threaded rods.
g) Blowoff outlet: With female NPT tapping.
h) Mueller model No. 781 for ANSI Class 150.
i) Mueller model No. 782 for ANSI Class 300.

B. Basket Strainers:

1. Chilled Water and Condenser Water Systems of Steel Construction:

a. Working pressure: To 250 psig, non-shock.

1) Sizes 1-1/4 inch to 16 inch: ANSI 150 lb. Class.

a) Connections: Flanged.
b) Body: Ductile iron, ASTM 395. With tapped and plugged drain connections.
c) Cover: A 515-70 plate. With non-asbestos gasket.
d) Basket to 8 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area. Closed bottom. With handles.
e) Basket 10 inch and larger: 5/32 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area. Closed bottom. With handles.
f) Mueller model No. 166 DI.

b. Working pressure to 285 psig at 100 deg F; ANSI Class 150 and 740 psig at 100 deg F, ANSI Class 300; non-shock:

1) Sizes 3/4 inch to 16 inch:

a) Connections: Flanged.
b) Body: Carbon steel, ASTM 126, Grade WCB. With tapped and plugged drain connection. With machined and gasket seat.
c) Cover flange: A515-70 plate. With non-asbestos gasket.
d) Basket to 4 inch: 1/16 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 6.6 times inlet area. Closed bottom. With handles.
e) Basket 5 inch to 12 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 6.6 times inlet area. Closed bottom. With handles.
f) Basket 14 inch and larger: 3/16 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 6.6 times inlet area. Closed bottom. With handles.
g) Mueller model No. 196CS for ANSI Class 300.

2. Chilled Water and Condenser Water Systems of Copper Construction:

a. Working pressure to 225 psig ANSI Class 150; to 400 psig ANSI Class 300:

1) Sizes 2 inch to 12 inch:

a) Connections: Flanged.
b) Body: Bronze, ASTM B62 (85-5-5-5). With tapped and plugged drain connections. With plugged gauge tappings.
c) Cover: Bronze ASTM B62 (85-5-5-5). With non-asbestos gasket.
d) Basket to 4 inch: 1/16 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area. Closed bottom. With handles.

e) Basket 5 inch to 12 inch: 1/8 inch perforations. 304 stainless steel, ASTM 240. Free area not less than 2-1/2 times inlet area. Closed bottom. With handles.
f) Mueller model No. 165B for ANSI Class 150.
g) Mueller model. No. 166 for ANSI Class 300.

C. Pump Suction Diffuser:

1. Working Pressure:

a. Sizes 2 inch to 12 inch: 110 psig at 300 deg F to 200 psig at 105 deg F, non-shock, wog.
b. Sizes 14 inch and larger: 150 psig at 150 deg F, non-shock, wog.
c. Connections:

1) To 2 inch: Threaded.
2) 2-1/2 inch and larger: Flanged.

d. Body:

1) Cast iron, ASTM 126, Class B.
2) With pad and female NPT tapping for base support.

e. Cover:

1) Cast iron, ASTM A126, Class B.
2) For sizes to 8 inch x 8 inch with quick opening ductile iron knobs and EPDM O-ring seal.
3) For sizes 10 inch x 8 inch and larger: Bolted with EPDM O-ring seal.

a) Nuts: Carbon steel ASTM A194-4.

f. Inlet vanes:

1) 304 stainless steel.

g. Orifice cylinder:

1) 304 stainless steel.

h. Start up screen:

1) 20 mesh.
2) 304 stainless steel.

i. Magnetic separator.

2. Working pressure:

a. Sizes to 12 inch: 565 psig at 300 deg F to 640 psig at 100 deg F, non-shock, wog.
b. Connections:

1) To 2 inch: Threaded.
2) 2-1/2 inch to 12 inch: Flanged.

c. Body:

1) Ductile iron, ASTM A536.
2) With pad and female NPT tapping for base support.

d. Cover:

1) Ductile iron, ASTM A536.
2) Bolted with EPDM O-ring seal.
3) Carbon steel ASTM A194-4.

e. Inlet vanes:

1) 304 stainless steel.

f. Orifice cylinder:

1) 304 stainless steel.

g. Start up screen:

1) 20 mesh.
2) 304 stainless steel.

h. Magnetic separator.

D. Vacuum Breakers

1. For service to 300 psig wsp, similar to Sarco VB 12:

a. Size: 1/2 inch.
b. Features:

1) All internals renewable without disturbing piping.

c. Construction:

1) Cap: Stainless steel, Type 303.
2) Valve: VB 12 stainless steel, Type 303.
3) Valve seat: VB 12 stainless steel, Type 303.
4) Body: VB 12 stainless steel, Type 303.
5) Gasket: VB 12 stainless steel, Type 304.
6) Connections:

a) System: 1/2 inch screwed NPT.
b) Air inlet: 1/8 inch screwed NPT.

E. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

A. Low Temperature Water System, IN EXCESS of 100 psig up to 300 PSIG, except as noted and 40 to 220 deg F supply temperature for hot water, condenser water, chilled water, primary and secondary brine, dual temperature water and glycol systems:

1. Material shall be steel in accordance with ASTM A 53, Grades A or B.
2. Wall thickness shall be:

    a. To 2 inch: Schedule 80 with threaded ends or Schedule 40 with socket weld ends.
    b. 2-1/2 inch to 10 inch: Schedule 40, butt weld ends only.
    c. 12 inch and larger: 0.375 inch wall thickness up to 250 psig, butt weld ends only.
    d. 12 inch and larger: 0.500 inch wall thickness greater than 250 psig and up to 400 psig, butt weld ends only

3. 4 inch and smaller up to 300 PSIG and 100 deg F or 150 PSIG and 250 deg F, Type K, drawn-temper copper tubing, wrought-copper fittings, and brazed joints
4. No threaded joints are allowed in glycol systems

B. Air-Vent Piping:

1. Inlet: Same as service where installed
2. Outlet: Same as service where installed .

C. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed

D. Provide dielectric fittings for connection of dissimilar metals. Use of bronze valves is not acceptable as a dielectric

### 3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install spring loaded check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at heat exchangers hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

## 3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, **NPS 3/4 (DN 20)** ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated. Slip-on flanges shall be back welded.

S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

## 3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 6 feet ; minimum rod size, 3/8 inch .
2. NPS 1 (DN 25): Maximum span, 6 feet ; minimum rod size, 3/8 inch .

3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 10 feet ; minimum rod size, 1/2 inch .
6. NPS 3 (DN 80): Maximum span, 10 feet ; minimum rod size, 1/2inch .
7. NPS 4 (DN 100): Maximum span, 10 feet ; minimum rod size, 5/8 inch .
8. NPS 6 (DN 150): Maximum span, 10 feet ; minimum rod size, 3/4 inch .
9. NPS 8 (DN 200): Maximum span, 10 feet ; minimum rod size, 3/4 inch .
10. NPS 10 (DN 250): Maximum span, 10 feet ; minimum rod size, 7/8 inch .
11. NPS 12 (DN 300): Maximum span, 10 feet ; minimum rod size, 7/8 inch (22 mm).
12. NPS 14 (DN 350): Maximum span, 10 feet ; minimum rod size, 1 inch (25 mm).
13. NPS 16 (DN 400): Maximum span, 10 feet ; minimum rod size, 1 inch (25 mm).
14. NPS 18 (DN 450): Maximum span, 10 feet; minimum rod size, 1-1/4 inches (32 mm).
15. NPS 20 (DN 500): Maximum span, 10 feet; minimum rod size, 1-1/4 inches (32 mm).

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 3/8 inch .
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 3/8 inch .
3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 1/2 inch .
6. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch .

F. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

G. Provide additional support at changes in direction, branch piping and runouts over 5 feet and concentrated loads due to valves, strainers and other similar items.

H. Vertical piping:

1. Base elbow support: Provide bearing plate on structural support, similar to F&S Manufacturing Co. Fig. 720 or 721.
2. Provide guides at every third floor but not exceed:

    a. 25 ft for piping to 2 inch.
    b. 36 ft for piping 2-1/2 inch to 12 inch.
    c. 50 ft for piping 14 inch and larger.

3. Top support: Provide special hanger or saddle in horizontal connection and make provisions for expansion.
4. Intermediate supports: Steel pipe clamp at floor. Bolt and weld to pipe with extension ends bearing on structural steel or bearing plates.
5. For multiple pipes, coordinate guides, bearing plates and accessory steel.

## 3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

## 3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

G. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

H. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

## 3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

## 3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping." Systems less than 100 psig, hydrostatically test to 150 psig.
5. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 1995 edition" and performance requirements and design criteria indicated.

1. DESIGN
   STATIC PRESSURE

| PRESSURE CLASS | OPERATING PRESSURE |
|---|---|
| 2 IN. W.G | UP TO 2 IN. W.G. |
| 6 IN. W.G. | OVER 2 IN. UP TO 6 IN. W.G. |
| 10 IN. W.G. | OVER 6 IN. UP TO 10 IN. W.G. or |

as indicated on plans

a. Based on the following:

1) Single duct system: Static pressure at respective point in ductwork during normal operation.
2) Variable volume and dual duct systems: Static pressure at beginning of fan discharge duct.

b. Description of ductwork pressure class and equipment:

1) 6” and greater Duct Class: All supply ductwork from discharge of fans, air handling units, or AC units to inlets of terminal boxes on floor, all outdoor ductwork and all ductwork running through unconditioned spaces. Seal Class “A”, for outdoor ductwork and B for indoor ductwork as defined by Table 6.4.4.2B of ASHRAE 90A-2004.
2) 2” Duct Class and less: All other low pressure ductwork. Seal Class “A” for outdoor, “B” for unconditioned space, “C” for conditioned space as defined by Table 6.4.4.2B of ASHRAE 90.1-2004.
3) Acoustic consultant requirement for 10 inch pressure class duct work for acoustic attenuation refer to Noise Control Section.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SEI/ASCE 7.

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

## 1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings (CAD Generated and Drawn to 3/8 scale):

1. Sheetmetal shop standards shall be compiled directly from the “SMACNA DUCT CONSTRUCTION STANDARDS- Metal and Flexible” manual. Modifications for a specific project, if any, shall be indicated directly on the SMACNA templates. Modified shop standards not taken directly from the SMACNA templates will not be accepted. Any deviations from SMACNA shall be noted.
2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
3. Factory- and shop-fabricated ducts and fittings.

4. Duct layout (double line) indicating sizes, transitions, configuration, liner material, and static-pressure classes.
5. Elevation of top of ducts.
6. Dimensions of main duct runs from building grid lines.
7. Sheet metal thicknesses
8. Fittings.
9. Reinforcement details and spacing.
10. Seam and joint construction and sealing
11. Materials, fabrication, assembly, and spacing of hangers and supports.
12. Penetrations through fire-rated and other partitions.
13. Equipment installation based on equipment being used on Project.
14. Access clearance for all equipment and accessories
15. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
16. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

D. Welding certificates.

E. Field quality-control reports.

## 1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, " Installation of Air conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations, "Ch. 3 "Duct System," for range hood ducts, unless otherwise indicated.

D. Indicate compliance with USGBC LEED rating criteria for Indoor environmental quality (IEQ.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", latest edition, based on indicated static-pressure class unless otherwisedicated.

B. The following fitting connections and duct construction gauges are NOT acceptable

1. Drive slip T-1, T-2 fitting connections
2. 26 gauge ductwork.

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Fittings and/or joints of two different gauges, connected joint rating shall meet more stringent conditions

1. Use the following SMACNA Transverse (Girth) Joints

a. Duct construction as follows for 2" w.g. class:

1) Up to 12" wide use T-6 or T-7
2) 13" to 28" wide use T-11 or T12
3) 29" wide and up use TDC or TDF

b. Duct construction as follows for 3" w.g. class:

1) Up to 20" wide use T-6 or T-7
2) 21" to 24" wide use T-11 or T12
3) 25" wide and up use TDC or TDF

c. Duct construction as follows for 6" w.g. class:

1) Up to 12" wide use T-6 or T-7
2) 13" to 18" wide use T-11 or T12
3) 19" wide and up use TDC or TDF

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## 2.2 SINGLE-WALL ROUND] DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Lindab Inc.
    b. McGill AirFlow LLC.
    c. SEMCO Incorporated.
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.

B. Provide spiral seams for all ducts and fittings.

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter (diameter of the round sides connecting the flat portions of the duct).

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, 1995 edition, Figure 3-2, 2005 edition, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," 90 Degree Tees and Laterals," and "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## 2.3 DOUBLE-WALL ROUND DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Provide spiral seams for all ducts and fittings

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter (diameter of the round sides connecting the flat portions of the duct) of the inner duct.

D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,90 Degree Tees and Laterals," and "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

"Perforated with acoustic lining in most common"

E. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.

## 2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", latest edition for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: [**Black**] [**White**].
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

G. Watertight construction where noted with edges bent 1/2 inch for watertight seal. Longitudinal seam sealant shall be similar to 3M Brand No. 800; Alcoa, aluminastic Type C, or solder. Stiffeners shall be plug or spot welded. Transverse joints shall be bolted companion angles with 1/4 inch cadmium plated bolts with 6 inch minimum on centers and gasket.

H. Air tight construction where noted with longitudinal seams soldered. Stiffeners shall be plug or spot welded. Transverse joints shall be bolted companion angle with 1/4 inch cadmium plated bolts with 6 inch minimum on centers and gasket. Exposed, uninsulated ductwork shall be flush

flat seam. Provide airtight concrete, masonry and other construction materials for plenums and shafts only where noted

## 2.5 DUCT LINER

A. Comply with requirements specified in Division 23 Section "NOISE CONTROL AND ACOUSTICAL PERFORMANCE ".

B. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream. .
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

## 2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Indicate compliance with USGBC LEED rating criteria for Indoor environmental quality (IEQ)

C. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches].
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

D. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

## 2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Rectangular Duct Hangers Minimum Size," and "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

## 2.8 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

## PART 3 - EXECUTION

### 3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal

flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

## 3.2 SEAM AND JOINT SEALING

A. All longitudal and transverse joints, seams and connections in metallic and non-metallic ducts shall be constructed as specified in SMACNA HVAC Duct Construction Standards – Metal and Flexible and NAIMA Fibrous Glass Duct Constructions Standards. All joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (Adhesives), mastic-plus-embedded-fabric systems or tapes. Tapes and mastics used to seal ductwork listed and labeled in accordance with UL 181A shall be marked “181A-P” for pressure-sensitive tape, “181A-M” for mastic or “181A-H” for heat-sensitive tape. Tapes and mastics used to seal flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic. Duct connections to flanges if air distribution system equipment shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked 181B-C. Unlisted duct tape is not permitted as a sealant on any metal ducts.

## 3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with the requirements of this section, the BUILDING CODE and SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"Rectangular Duct Hangers Minimum Size," and "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing whichever is more stringent. Install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Hangers, horizontal ducts:

1. To 2 sq ft in area: Provide galvanized steel strap hangers, minimum 1 inch x 1/8 inch, maximum 8 ft - 0 inch spacing.
2. 2 to 4 sq ft in area: Galvanized steel strap hangers, minimum 1 inch x 1/8 inch, maximum 8 ft 0 inch spacing.
3. Strap hangers shall be bent 2 inch under the bottom corner of rectangular ducts. One screw shall secure 2 inch portion of hanger to bottom of duct. Straps shall be secured to side of duct with a minimum of two screws and more, as necessary, to provide a maximum screw spacing of 12 inch. Side-of-duct screws shall be located not more than 2 inch from top and bottom of duct.
4. 4 to 10 sq ft in area: Provide galvanized steel trapeze angles from steel threaded rods with a maximum 6 ft - 0 inch spacing.
5. Over 10 sq ft in area: Provide galvanized steel trapeze angles from steel threaded rods with a maximum 4 ft - 0 inch spacing.
6. Provide stronger support to match larger and heavier ducts; provide cross-bracing, angle iron hangers, as required for rigid and adequate supports.
7. In mechanical rooms: Provide black steel painted or galvanized, vertical angles or rods and horizontal angles across ductwork.

H. Hangers Vertical ducts: At each floor, provide minimum 2 supports per duct fastened to duct and spanning shaft opening. Fasten supports to floor or structural construction. Maximum screw spacing shall be 12 inch on center and maximum shall be four screw per riser.

1. Angles and channels: Provide painted black steel or galvanized. Where angles are specified, channels of equivalent strength, material and protective coating will be permitted. Where more than one duct is supported by a common set of angles, support size shall be determined by sum of width dimensions.
2. Supports: Provide as follows, except increase supports as required for load and span where span of angles exceed 6 ft or floor-to-floor height exceeds 14 ft.

    a. Duct width to 30 inch: Provide angle size: 1-1/4 inch x 1-1/4 inch x 1/8 inch.
    b. Duct width, 31 inch to 54 inch: Angle size shall be 2 inch x 2 inch x 3/16 inch.
    c. Duct width, 55 inch to 90 inch: Angle size shall be 2 inch x 2 inch x 1/4 inch.

3. Vertical kitchen exhaust, fireproofed and plastered ducts: Provide minimum 3 inch, 4.1 lb/ft, steel channels fastened to slab, welded to building structural steel or as acceptable. Supports shall be bolted or welded to ducts.

## 3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

F. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

## 3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

## 3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

## 3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
2. All testing shall be done in the presence of the engineer or owner's representative. The contractor is responsible for providing all collars, caps, electric power, etc. necessary to perform the tests. The contractor is also responsible for scheduling the test no less than three (3) business days prior to its intended occurrence. Low pressure ductwork (2" class) shall be tested on an as needed basis at the engineer's direction. Leakage test procedure shall follow the outlines and classifications in the SMACNA HVAC duct leakage test manual. If specimen fails to meet allotted leakage level, the contractor shall modify to bring it into compliance and shall retest it until acceptable leakage is demonstrated. Tests and necessary repair shall be completed prior to concealment of ducts.
3. Test the following systems:

    a. All ductwork greater than 2" class as defined within is to be tested. .

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before insulation application.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

## 3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as follows:

1. Outside air, exhaust and relief duct shall be as follows:

a. Aluminum.
b. Watertight.
c. Extent:

1) Within 10 ft. of louvers.
2) Louvers to casings.
3) Louvers to preheaters.

B. Liner:

1. Comply with requirements specified in Division 23 Section "NOISE CONTROL AND ACOUSTICAL PERFORMANCE ".

C. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Rectangular Elbows."

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Vanes and Vane Runners," and "Vane Support in Elbows."
3) Provide vanes on all short radius elbows.
4) Provide double thickness turning vanes on all square elbows.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments, conform to SMACNA.

1) Velocity 1000 fpm or Lower: 0.6 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

D. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Branch Connections."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.
    b. Rectangular Main to Round Branch: flanged spin in, conical.
    c. Do not use “butt flange” straight taps.
    d. Divided flow branches
        1) Provide long radius takeoff or square elbow as per SMACNA.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"90 Degree Tees and Laterals," and "Conical Tees."

    a. Velocity 1000 fpm or Lower: 90-degree tee fitting.
    b. Velocity 1000 to 1500 fpm: Conical fitting.
    c. Velocity 1500 fpm or Higher: 45-degree lateral fitting.
    d. Saddle taps are NOT permitted.
    e. No bull head tees
    f. Divided flow branches, conical tees, y- branch or reducing Y-branch.or Tee’s

E. Obstructions

1. Conform to SMACNA

F. Offsets and transitions

1. Conform to SMACNA

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Manual volume dampers.
   2. Control dampers.
   3. Fire dampers.
   4. Combination fire and smoke dampers.
   5. Flange connectors.
   6. Turning vanes.
   7. Remote damper operators.
   8. Duct-mounted access doors.
   9. Flexible connectors.
   10. Duct accessory hardware.

B. Related Sections:
   1. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

      a. Special fittings.
      b. Manual volume damper installations.
      c. Control damper installations.

d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

## 1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

## 1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts and **No 4** finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.2 MANUAL VOLUME DAMPERS

A. Dampers to be the same as duct construction.

B. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Pottorff; a division of PCI Industries, Inc.
    b. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Hat-shaped, galvanized -steel channels, 0.064-inch minimum thickness.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Provide single blade dampers up to 6 inch width and opposed multtiblade dampers above 6 inches in width.
    c. Parallel- or opposed-blade design.
    d. Stiffen damper blades for stability.
    e. Galvanized -steel, 0.064 inch thick (16 ga.).

6. Blade Axles: Galvanized steel .
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

C. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Pottorff; a division of PCI Industries, Inc.
    b. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
    e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

6. Blade Axles: Stainless steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

D. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Pottorff; a division of PCI Industries, Inc.
    b. Ruskin Company.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Hat shaped.
    b. Galvanized -steel channels, 0.064 inch thick.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, 0.064 inch thick. (16 ga.).

6. Blade Axles: Galvanized steel or Stainless steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered aluminum.
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements,:

    a. Ruskin Company.
    b. Trox USA Inc.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat -shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
    d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

6. Blade Axles: Galvanized steel or Stainless steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered aluminum.
10. Tie Bars and Brackets: Aluminum.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

F. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

G. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

## 2.3 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pottorff; a division of PCI Industries, Inc.
2. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to [**4-inch wg**] static pressure class and minimum [**4000-fpm**] velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame**:** Curtain type with blades outside airstream ("Type B"); fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

K. Heat-Responsive Device: Electric resettable link and switch package, factory installed, [**165 deg F**] [**and**] [**212 deg F**] <**Insert temperature**> rated.

L. The HVAC contractor shall provide all devices, relays, end switches, e/p switches, control components, air piping, power wiring, control wiring and interlock wiring as required to accomplish the sequence of operation for these dampers.

M. Provide fire dampers as noted on the plans and in ducts and openings in the following:

a. Shafts.
b. Floors.
c. Fire walls.
d. Fire-resistance partitions.
e. Fire rated ceilings.
f. Exit corridor walls.

N. Provide access door in duct adjacent to each fire damper.

O. Provide access door in duct adjacent to each combination fire / smoke damper.

## 2.4 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pottorff; a division of PCI Industries, Inc., model FSD-151, FSD-341, 1-1/2 or 3 hours rated as applicable
2. Ruskin Company.model FSD-60, 1-1/2 or 3 hour rated as applicable

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: multiblade type fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated. Provide dual temperature heat responsive device.

H. Blades: 14 gauge galvanized airfoil shaped double skin, single piece construction, maximum 6 inches wide..

I. Leakage: Class I .

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

L. Provide motor mount bracket strengthener for dampers over 10" in height.

M. Provide a 10 gauge welded vertical stiffener at each corner to prevent damper misalignment

N. Master control panel for use in dynamic smoke-management systems.

O. Damper Motors: two-position action.

P. Actuators mounted out of the air stream,

Q. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Electrical Connection: 115 V, single phase, 60 Hz.

R. Accessories:

1. Auxiliary switches for position indication.
2. Test and reset switches, remote mounted.

S. The HVAC contractor shall provide all devices, relays, end switches, e/p switches, control components, air piping, power wiring, control wiring and interlock wiring as required to accomplish the sequence of operation for these dampers.

T. Provide combination fire / smoke dampers as noted on the plans and in ducts and openings in the following:

a. Shafts.
b. Floors.
c. Fire walls.
d. Fire-resistance partitions.
e. Fire rated ceilings.
f. Exit corridor walls.

U. Provide access door in duct adjacent to each combination fire / smoke damper.

## 2.5 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.

B. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; "Vanes and Vane Runners," and "Vane Support in Elbows."

D. Vane Construction: Double wall.

E. The maximum unsupported vane length shall not exceed 48 inches.

F. Single vane and short radius vanes are not acceptable.

## 2.6 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Greenheck Fan Corporation.
3. McGill AirFlow LLC.
4. Pottorff; a division of PCI Industries, Inc.
5. Ventfabrics, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside handles.
    d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 10-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

## 2.7 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

## 2.8 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.
3. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip [**3-1/2 inches**] [**5-3/4 inches**] wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

## 2.9 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts."Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.
3. Provide manual balancing volume dampers as required properly balance the air distribution system. If the location of balancing dampers are not defined on the drawings, the following minimum standards shall govern:

    a. Low Pressure: All supply main air branches from trunk, each split, and all sub branches from main shall be provided with balancing dampers.
    b. Low Pressure: All exhaust main air branches from trunk, each split, and all sub branches from main shall be provided with balancing dampers.
    c. Medium Pressure: All branches and takeoffs downstream of terminal boxes (CV, VAV and FPB) shall be provided with balancing dampers.
    d. Ducts connecting to common plenums.
    e. Ducts serving single outlet.
    f. At open return duct in hung ceiling.
    g. As noted on plans.

4. For internally lined ductwork: Provide 2 internal saddles to protect lining.
5. Install levers to be accessible through the insulation

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install, [**combination fire & smoke**] fire[ **and smoke**] dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch- diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars

to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Downstream from manual volume dampers, control dampers,[ **turning vanes,**] and equipment.
3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
4. At each change in direction and at maximum 50-foot spacing.
5. Upstream of turning vanes.
6. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

L. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts directly. Do not use flexible ducts.rovide flexible connections for all fan powered terminal boxes.

P. Connect diffusers to low-pressure ducts directly.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

## 3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Centrifugal roof ventilators.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

   1. Certified fan performance curves with system operating conditions indicated.

   2. Submit the family of rpm curves indicating operating point relative to fan class.
   3. Drive construction and rating.
   4. Catalog cuts and dimension drawings.

   5. Submit all selected sheave (fan and motor) calculations.

   6. Correction chart for fans equipped with variable inlet vanes indicating performance at various percentage of opening.

   7. VFD application: Submit fan selection with system curve indication, operating point, family of all rpm curves in fan class and the "DO NOT SELECT TO THE LEFT OF THIS CURVE". The minimum rpm shall be indicated.

   8. Certified fan sound-power ratings.
   9. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   10. Material thickness and finishes, including color charts.
   11. Dampers, including housings, linkages, and operators.
   12. Roof curbs.

13. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

## 1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
1. Test and rate all fans in accordance with the standards of AMCA. All fans shall bear the AMCA rating and seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

2. Sheaves : One set for each unit

PART 2 - PRODUCTS

2.1 GENERAL

A. Make appropriate allowances for the effects on fan performance of all installation conditions including plenum enclosures and inlet and discharge arrangements so that actual installed fan performance equals that specified.

B. Fans shall be non-overloading and operate stably without surging at design conditions.

C. Fan characteristic curves provided by manufacturer must be such that that the fan operating point:

1. Is to the right of peak efficiency.

2. Is on the steep part of the fan curve such that an increase in static pressure over the specified duty results in not more than the same percent decrease in volume (CFM) and does not affect the stability of fan operation.

3. Is no greater than 60 to 70 percent of the peak static pressure.

4. Has the ability to provide an allowable increase in fan speed of 15 percent above the design point without surging or increasing the class of fan.

D. Provide non-overloading design, except as noted with minimum capacities as noted and with certified ratings by AMCA. Where variable inlet vanes are used, complete assembly shall be factory installed by the fan manufacturer. The fan horsepower performance characteristics shall be within 5 percent of published catalog rating data of the standard fan without the variable inlet vanes, where no data is available for the fan with inlet vanes. Inlet vanes shall be capable of reducing flow to 20 percent of design cfm at 1-1/2 inch w.g. static pressure and maintain stable performance. Inlet vanes and all operating linkages shall be provided and assembled by fan manufacturer prior to shipment to job site.

E. Wheel shall be factory balanced statically and dynamically. Brake horsepower ratings shall be 5 percent maximum above those noted and published for a minimum of two (2) years.

F. Motor pulley shall be variable pitch diameter, for fans up to 25 hp and 1000 rpm, except fans with variable inlet vanes and VFD's use fixed pitch, and fixed pitch diameter, over 25 hp or 1000 rpm. Supply and install one fixed pitch pulley change, as required, per fan to balance systems. Companion sheaves shall maintain belts parallel. Belt guards shall be in compliance with OSHA regulations and with tachometer opening for fan speed measurements. Manufacturer shall provide replacement fixed pitched sheaves where needed to balance system.

G. Provide removable flanged screens at inlets or outlets where no connecting ductwork is indicated, including inlets to fans in field erected casings.

H. Bearings shall be ball, roller or taper. Provide pressure type lubricating fittings with pressure relief fittings extended to accessible locations. lubricating fittings shall be similar to Alemite. Pressure relief fittings shall be similar to Keystone. For fans 27 inch and larger, provide housings horizontally split, roller bearings.

I. Provide spark resistant construction fans in accordance with AMCA Standards Type A, B or C. Type A: All where noted, parts in contact with air shall be non-ferrous. Type B shall be non-ferrous fan wheel and shaft rings. Type C shall be with non-ferrous inlet cone and rubbing plate. Motor shall be explosion proof, Class I, Group D, Division 2. Belt drive shall be non-sparking.

J. Split construction: Provide split construction for fans too large for available doorways or passageways. Split in half along center of shaft with angles, etc., to allow removal of section without disturbing inlet and discharge connection; arranged for bolting. Provide bolts with lockwashers and nuts. Construction shall be inspected by manufacturer after field assembly and certified that they have been properly assembled and ready for proper operation.

K. The drive end of the fan shaft shall be countersunk for tachometer readings.

L. For all fans located outdoors, except roof ventilators exposed to the weather, provide custom fitted weather guards completely enclosing the fan motor, drive and bearings. Provide weatherproof louvers in the enclosure to permit circulation of air but to exclude rain and snow. Arrange one side of the enclosure to be completely removable for access to motors, drives, bearings and other equipment located within requiring maintenance. Construct the enclosure of 16 gauge aluminum, braced with aluminum angles. Paint the fan exterior with two coats of weatherproof aluminum paint.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aerovent; a Twin City Fan Company
   2. Greenheck.
   3. Loren Cook Company.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

   1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   4. Fan and motor isolated from exhaust airstream.

F. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

   1. Configuration: Self-flashing without a cant strip, with mounting flange Built-in raised cant and mounting flange.
   2. Overall Height: 12 inches.
   3. Damper Access extension: Provide 8" high aluminum with removable access panel.

   4. Sound Curb: Curb with sound-absorbing insulation matrix.
   5. Pitch Mounting: Manufacture curb for roof slope.
   6. Metal Liner: Galvanized steel.
   7. Mounting Pedestal: Galvanized steel with removable access panel.
   8. Vented Curb: Unlined with louvered vents in vertical sides.

2.3 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

B. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

## 3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Balance all fan wheels and all other moving components statically and dynamically. Where a coating is specified and it affects the balance of the fan wheel, perform the balancing after the coating has been applied.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. For units with variable frequency drives lock out critical frequencies before initial start.
13. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
14. Replace fan and motor pulleys as required to achieve design airflow.
15. Shut unit down and reconnect automatic temperature-control operators.
16. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

## 3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

## 3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 233423

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:

   1. Instructions for resetting minimum and maximum air volumes.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers:

1. Anemostat; a Mestek Company.
2. Titus.

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 0.034-inch steel.

1. Casing Lining: 1/2-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil.

2. Casing Lining: Adhesive attached, 3/4-inch- thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
4. Air Outlet: S-slip and drive connections.
5. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
1. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

F. Attenuator Section: 0.034-inch steel sheet metal.

1. Lining: 1/2-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil.
2. Lining: Adhesive attached, 3/4-inch- thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

G. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] <**Insert number**> [**6-inch-**] [**8-inch-**] [**10-inch-**] diameter collars; each with locking butterfly balancing damper.

H. Electric Heating Coil: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

1. Primary and secondary overtemperature protection.
2. Nickel chrome 80/20 heating elements.
3. Airflow switch.
4. Noninterlocking disconnect switch.
5. Fuses (for coils more than 48 A).
6. Mercury contactors.
7. Pneumatic-electric switches and relays.
8. Magnetic contactor for each step of control (for three-phase coils).

I. VAV Boxes

1. Controls

a. DDC Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC."

2. Control Sequence:

a. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.

b. Factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay.

## 2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

## 3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

D. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

## 3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

## 3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and do the following:

a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
b. Verify that controls and control enclosure are accessible.
c. Verify that control connections are complete.
d. Verify that nameplate and identification tag are visible.
e. Verify that controls respond to inputs as specified.

## 3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Perforated diffusers.
4. Louver face diffusers.
5. Linear slot diffusers.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.

3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

E. Source quality-control reports.

## PART 2 - PRODUCTS

### 2.1 CEILING DIFFUSERS AND REGISTERS

A. Round Ceiling Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white Baked enamel, color selected by Architect.
5. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

B. Rectangular and Square Ceiling Diffusers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, color selected by Architect.
5. Face Size: 24 by 24 inches.
6. Face Style: Plaque.
7. Mounting: Surface.
8. Pattern: Two position.
9. Accessories:

    a. Equalizing grid.

b. Plaster ring.
c. Safety chain.
d. Wire guard.
e. Sectorizing baffles.
f. Operating rod extension.

C. Perforated Return:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel backpan and pattern controllers, with steel face.
4. Finish: Baked enamel, color selected by Architect.
5. Face Size: 12 by 12 inches.
6. Duct Inlet: Round.
7. Face Style: Flush.
8. Mounting: Surface T-bar.
9. Pattern Controller: Four louvered deflector patches.
10. Accessories:

a. Equalizing grid.
b. Plaster ring.
c. Safety chain.
d. Wire guard.
e. Sectorizing baffles.
f. Operating rod extension.

D. Linear Slot Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: Steel,.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: Baked enamel, black.
6. Finish - Pattern Controller: Baked enamel, black.
7. Finish - Tees: Baked enamel, color selected by Architect.
8. Slot Width: 3/4 inch.
9. Number of Slots: Two.
10. Length: As specified on drawings.
11. Accessories: [**Plaster frame**] [**T-bar slot**] [**Center notch**] [**T-bar on inlet side**] [**T-bar on both sides**] [**T-bar clip on one side**] [**T-bar clips on both sides**].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Only four (4) way diffusers shall be provided. Provide sheetmetal blank off as required for 1 way, 2 way or 3 way diffusers.

E. Noise level at noted capacities shall not exceed criteria specified in Section NOISE CONTROL. Diffusers shall be suitable for operation at 5 percent excess and 25 percent less then noted capacity. Provide blanking for proper coverage and blow without producing objectionable noise or air motion at occupied level. Finish shall match color sample as approved:

F. Linear diffusers: Frame types shall mate with ceilings. Provide means to neatly butt and align units to give continuous appearance without butting flanges. No screw holes or welded corners visible on diffusers or frames will be permitted. Air volume shall be adjustable through air supply face without requiring removal of face panel. Provide blanked sections for inactive lengths. Provide plaster frames and opposed blade volume dampers with remote cable operators where noted. Refer to Architectural Drawings for mounting details and overall lengths. Finish shall match color sample as approved:

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713